DOCUMENT RESUME

ED 146 443 CE 013 764

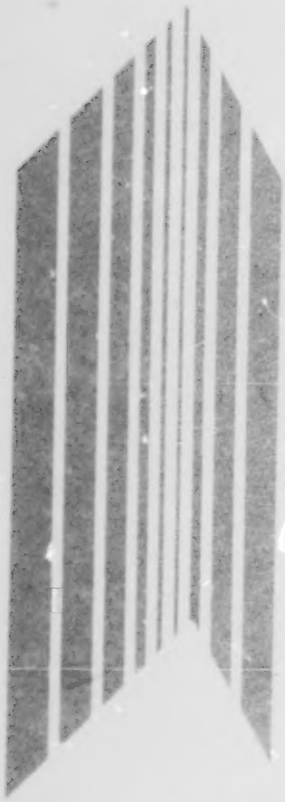
| | |
|---|---|
| TITLE | Projections of National Requirements for Dentists. 1980, 1985, & 1990. Health Manpower References. |
| INSTITUTION | Health Resources Administration (DHEW/PHS), Bethesda, Md. Div. of Dentistry. |
| REPORT NO | DHEW-HRA-77-48 |
| PUB DATE | Jul 77 |
| NOTE | 92p. |
| EDRS PRICE | MF-$0.83 HC-$4.67 Plus Postage. |
| DESCRIPTORS | Dental Assistants; Dental Health; Dental Hygienists; Dental Technicians; *Dentists; *Employment Projections; *Labor Market; *Labor Supply; *Manpower Needs; National Surveys; Paraprofessional Personnel; Trend Analysis |
| IDENTIFIERS | United States |

ABSTRACT

To provide a general picture of how the private dental office personnel picture is expected to evolve under particular assumptions, this report presents the projections of the national supply and requirements for dentists for 1980, 1985, and 1990. General implications for dental auxiliary personnel are also discussed. Factors determining the demand and supply of dental services, which include past demand, population growth, economic growth, dental insurance coverage, and technological progress, are analyzed along with developing trends in dentistry and their anticipated effects on supply and demand. Areas identified for needed additional research include dental prepayment and fluoridation. A fifty-six-page appendix descrites in detail the supply-demand forecast model used and examines past and developing trends which affect dental supply and demand relationships: engineering advances, organizational change in dentistry, prevention of dental disease, and third-party payment. (BI)

**********
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
**********

ED146443



# Projections of
# NATIONAL REQUIREMENTS FOR DENTISTS
## 1980, 1985, & 1990

HEALTH MANPOWER REFERENCES

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

July 1977

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Health Resources Administration
Bureau of Health Manpower
Division of Dentistry

Center Building
3700 East-West Highway
Hyattsville, Maryland 20782

DHEW Publication No. (HRA) 77-18

CE 013 764

## PREFACE

This document presents the projections of the national supply and requirements for dentists as made by the Division of Dentistry in FY 1977. The projections cover the span of time from 1980 to 1990, and are intended to provide a general picture of how the private dental office personnel situation is expected to evolve under particular assumptions. Although the major emphasis of the projections is on requirements for dentists, the general implications for dental auxiliary personnel are discussed at some length.

The projections presented here are for national aggregate requirements. The distributional implications of these aggregate projections are not treated here; they will be addressed in a subsequent paper which will report the Division's efforts to disaggregate the national projections to the regional level.

Although the technique used to make the dental manpower requirement projections described here is a major improvement over methods previously employed by the Division, some elements of arbitrariness and subjectivity still remain. Recognizing this, the Division hopes that the approach presented here will provide a generally acceptable framework within which a disciplined discussion of the issues can be pursued, and that others will find the technique applicable to other fields where future requirements for manpower must be predicted. Because the technique does

depart from traditional approaches to predicting manpower requirements, the technical approach, as well as the considerations underlying our decisions about altering past trends for future projections, are documented in appendixes.

Under the direction of Jesse S. Hixson, Chief of the Manpower Assessment Section, the following staff members contributed to the development and preparation of this report: Nina Mocniak, John S. Small, Lawrence W. Walker, and Joann L. Boone.

CONTENTS


| | | |
|---|---|---|
| Chapter I. | Purpose and Approach | 1 |
| Chapter II. | Projected Requirements for Dentists | 9 |
| Chapter III. | Developing Trends in Dentistry: Conclusion | 21 |
| Chapter IV. | Additional Research Needed | 27 |
| Appendix A: | The Demand and Supply of Dental Services | 31 |
| Appendix B. | Past and Developing Trends in Dentistry | 51 |
| | Engineering Advances | 52 |
| | Organizational Change in Dentistry | 56 |
| | Prevention of Dental Disease | 66 |
| | Third Party Payment | 76 |

Chapter I

## PURPOSE AND APPROACH

The purpose of the projection exercise reported in this document is to compare the projected future output of dental personnel with projected future requirements so that the adequacy of the anticipated output can be assessed. Such an exercise is necessary because the production of health personnel is greatly affected by discretionary action in the public sector. Consequently, conscious decisions must be made to tailor the output of the manpower production system to the future requirements for personnel that will be generated by activity in the private sector of the economy.

Requirements for personnel are likewise influenced by policy and discretionary action in the public sector. This reinforces the necessity for assessing the adequacy of productive capacity and anticipated future output. But because few policy actions that significantly affect manpower requirements are sufficiently predictable, they are seldom considered in projections such as the ones presented in this paper. Rather, the difficulty of predicting their character and timing necessitates coordination of both supply-determining and requirement-determining policies. The need for such coordination is especially acute when precipitous requirement-determining policies, such as the enactment of a National Health Insurance Program, are contemplated.

The technical approach to predicting future requirements for dental personnel used in this paper is projection, as opposed to forecasting. The two approaches are distinguished by the fact that projections are based on the general assumption that what has gone on in the past will continue to go on in the future, while forecasting involves attempts to predict future changes based on knowledge of cause-and-effect relationships. Forecasting requires a much more sophisticated analytical technique than does projection. A forecasting model is currently being developed by the Division of Dentistry; however, until it is perfected to such a state that it can produce better predictions than the current projection technique, the Division will continue to use projection as its method for predicting future requirements for dental personnel.

As stated above, the purpose of these projections is to provide a guide for policy. There are two distinct sides to the health care policy problem: the demand side upon which policy must operate to convert perceived need for services into effective demand in the health services markets; and the supply side upon which policy must operate to assure that sufficient resources are forthcoming to satisfy the effective demand. Supply-side policy can have little effect on problems which are due to lack of effective demand in the markets for health services. This is why, for example, unmet "need" for health care can seldom be effectively addressed by manpower policy, whereas demand for health care which is unmet is a very relevant and practical concern for manpower

policy. Failure to make a clear distinction between "need" and effective demand impedes the making of defensible projections of manpower requirements. These projections do not attempt to recommend standards for consumption of dental care or for the utilization of dental personnel. Rather, they attempt to project the course of events that can be realistically expected to unfold over the next one and one-half decades and to detect the significant implications for the amounts of dental personnel that will be required to meet the effective demand for dental services that will be realized in the future. The concepts upon which these projections of dental manpower requirements are based are those of demand and supply. The focus of the approach is on the question of how many dentists will be required to supply the future demand for dental services. This paper reports projection of the amounts of manpower resources that will actually be utilized under specific assumptions about the future demand and supply of dental services.

The approach used for these projections can be contrasted to alternative approaches that have been used for many previous projections of manpower requirements [1]. For example, the traditional approach has been that of the "dentist-to-population ratio" in which a normative value of the ratio is chosen as a basis for assessing the "adequacy" of projected dentist-to-population ratios. Another approach uses patient visits as a measure of utilization, and attempts to project future utilization and dentists' capability to accommodate the projected utilization. Both of these approaches, as they are typically followed,

neglect the distinct aspects of supply and demand that must be considered independently to arrive at a credible representation of reality and to arrive at an objective view of future manpower requirements to meet the anticipated demand for services. The approach used in this paper focuses separately on the determinants of both demand and supply, and emphasizes the mechanisms that operate, primarily in the market, to bring demand and supply into balance with each other.

The variables affecting the demand for dental services considered in these projections are the price of dental services, national personal income, the size of the population, and the extent of third party payment for dental services. The variables affecting the supply of dental services that are examined are the price of services, the number of dentists, and the state of technology. The historical effects of these variables on demand and supply were examined with a statistical model of demand and supply which is discussed in detail in Appendix A. Fitting the model to historical data yielded estimates of the impact on supply and demand of changes in these variables over time. To determine the requirements for dentists in future years, the future demand for dental services was projected on the basis of projections of the growth of the population, of the economy and of prepaid dental benefits. The number of dentists required to meet the projected demand was then calculated for each of the years 1980, 1985, and 1990.

Given the demand expected to prevail at any given time, how many dental personnel will be required to "meet" or satisfy the demand? The fact is that, by virtue of the operation of various market mechanisms, demand can be satisfied within a wide range of numbers of dental personnel. Given a particular level of demand for services, a number of variables (for example, prices of services, employment of auxiliaries, dentists' hours and income) will adjust to achieve an equilibrium or balance between supply and demand such that the underlying behaviors of both suppliers and demanders in the market are mutually consistent with each other. No single variable, such as the number of dentists, can be singled out and treated in isolation.

The entire system must be studied as a whole, conceptualized in terms of supply and demand and the many variables affecting the behavior and choices of both consumers and producers. Moreover, the dental service and manpower markets are affected by forces which are beyond the control of manpower policy makers or of the Government in general. Particularly in the short run, the ability of manpower policy to deal with perceived "shortages" or "surpluses" of personnel is essentially impotent both because of the long lag between the decision to implement a policy and the realization of results, and because of the fact that the economic condition of the markets for dental services is tied so closely to the condition of the economy as a whole. For these reasons, questions like "how many dentists are required?" must be approached from a system-wide, long-run perspective.

In the short-run, the dental personnel scene is continually fluctuating around a stable long-run trend relative to which it might be said that there are "too many" or "not enough" personnel, depending on the subjective view of the observer. There is some range on either side of this trend, however, which contains the extent of expected or "normal" fluctuation; observing the state of affairs within this range on one side or the other of the trend from time to time would not alarm a neutral observer. For, it is to be expected that through the course of the cyclical fluctuations of the aggregate economy, the demand for dental services will also follow a cyclical pattern reflecting, at any given time, the current state of the national economy. Consequently, as long as the state of the market for dental care remains within the range of fluctuation that is consistent with the overall current state of the economy, a change in policy or other Government intervention would neither be warranted nor effective. Fluctuations outside this range would provide cause for alarm, however, and a change in policy or some other corrective action would be indicated. But, within the range of acceptable fluctuation, demand is met more or less adequately, the exact level being determined by the operation of market mechanisms through the movement of prices, incomes of dentists and employment of auxiliary dental personnel, waiting periods for appointments and other means by which supply and demand are brought into balance.

In summary, the approach to projecting the national requirements for dentists reported in this paper is based on the concept of the long-run balance of supply and demand around which the short-run equilibrium

is continaully fluctuating. An inflation-free long-run balance of supply and demand is regarded as the objective, and the projection of requirements aims at establishing where this balance will lie in the future. The numbers of dentists required to maintain the balance with demand are those necessary to maintain the long-run inflation-free trend, after adjustments are made for factors that have caused or are expected to cause shifts in the trend. Such factors included technological changes, changes in methods of financing dental care, progress in preventing dental diseases, and increased use of dental auxiliaries.

In the next chapter, the requirements projections for dentists are presented. The projections are based on past trends of the variables; in Appendix B, the developing forces that might alter the past trends in the variables determining the supply and demand for dental services are discussed. Our conclusions about the nature of these forces and their future effects are discussed in Chapter III; Appendix B provides a detailed discussion of the many factors considered in arriving at our conclusions. Appendix A presents a detailed economic analysis of the demand and supply of dental services at the national level, and presents the model of supply and demand which was the basis of the projections. Additional research needed to strengthen the model and the projections is discussed in Chapter IV.

References for Chapter I

1. Born, David O. "Dental Manpower Planning and Distribution. A Survey of the Literature." Advances in Socio-dental Research, Volume 2. American Dental Association, Chicago, 1975.

## Chapter II

## PROJECTED REQUIREMENTS FOR DENTISTS

The projections of requirements reported in this chapter were produced in a three-step process. First, the factors determining the time path of the quantity of dental services consumed in the U.S. over the period 1950-1970 were analyzed by estimating a model of supply and demand. This model estimated the long-run trend of the balance between supply and demand, and provided the appropriate weights to give to each of the separate factors used to project supply and demand. Second, the future demand for dental services in 1980, 1985, and 1990 was projected on the basis of estimates of the future rate of growth of the demand-determining factors. These were the size of the population, personal income and the extent of dental insurance coverage. Third, the requirements for dentists were projected by calculating the number of dentists required to bring the supply of services into balance with the projected demand for services to maintain the long-run trend established in the first step.

Basic to using "projection" as a technique for predicting the future is the assumption that what has characterized the past will continue to characterize the future. Therefore, the first task in the projection process is that of establishing the historical relationships between the variables of interest and the variables which influence or determine them. This task was accomplished by statistically estimating the parameters of a simultaneous equation model of supply and demand for

dental services. The technical details of the specification of the model are discussed in Appendix A. The focus of the statistical analysis which underlies the projections was the determination of the historical effects of past changes in the variables known to be important determinants of the supply and demand for dental services. In the analysis of demand, primary attention was given to the relationship between demand and the growth of the population, family disposable income, and the proportion of the population covered by dental insurance. On the supply side, the major factors treated were the effects on the supply of dental services of increases in the number of dentists and the advance of technology. All the variables mentioned above, which determine the state of the market for dental services, can be projected with some degree of confidence. Consequently, they are the variables which are typically used for projection purposes. The sources of the projected variables were the following.

Population

The projection of population growth employed in the dental services demand projection was the Census Bureau's Series II [3], which is generally regarded as the most representative of current trends. Series II assumes that the fertility rate will gradually increase from the current rate of 1.8 to a rate of 2.1 births per woman during childbearing years in the year 2025.

Economic Growth

The projections of economic growth are those of the National Planning Association (NPA). Using a long-range econometric model, the

NPA has forecast that the aggregate economy will grow at an average real rate of 3.9 percent per year through 1985 [2]. This figure was assumed to prevail through 1990.

Dental Prepayment

The growth of insurance coverage in the private sector was projected at a rate of 17 percent per year through 1980 [1]. It is projected that by 1990 the extent of coverage will reach 43 percent and maybe as much as 50 percent. The basis for these projections is discussed in detail in Appendix B. The projection of requirements for dentists does not deal with the prospect of national health insurance. Although it is probable that some type of national health insurance scheme will be enacted before the end of the period in question, the timing of its appearance is unpredictable. Nor are the coverage and benefit provisions of a national insurance scheme predictable. In all likelihood, if dental benefits are included at all, they will be phased in incrementally with initial coverage only for the very young. Consequently, the chance that national health insurance will be a significant demand-determining factor with respect to dental services in excess of that projected during the period under consideration seems small indeed.

Technological Progress

The projected rate of technological progress was obtained directly from the estimated supply function of the supply and demand model discussed in Appendix A. Technological advances are expected to contribute to the growth of supply at an average rate of 2-3/4 percent per

year. Technological change is manifested in the use of various types of improved materials and equipment over the years, as well as in the development of alternative methods of dental practice organization and division of labor in the delivery of service. These engineering and organizational developments are discussed in detail in Appendix B.

The analysis omitted several variables or factors which often receive attention in attempts to forecast or project the future state of the market for dental services. Omitted were the effects of water supply fluoridation, and the use of auxiliary personnel by dentists. The reasons for not explicitly including them in the analysis are the following.

It has been customary in past projections of dental personnel requirements to take into account the impact of community water fluoridation. For example, in past projections the Division of Dentistry has assumed that the effect of fluoridation would be to reduce the number of dentists required in 1980 by two percent below what the number would have otherwise been. At this point in time, however, the potential effects of fluoridation on the future demand for dental services are less apparent than they were previously. For, while it is clear that fluoridation reduces the incidence of dental caries in younger population groups, the implications of older population groups retaining more of their natural teeth as a result of access to fluoridated water in their younger years are uncertain because of their continuing later susceptibility to additional oral disease, particularly periodontal

disease. Because of the degree of uncertainty surrounding the effects on the demand for dental services of adult populations who experienced the advantages of community water fluoridation since their childhood years, fluoridation was not included as a variable in the statistical analysis. The possible implications of fluoridation for the future demand for dental services will, however, be discussed in detail in Appendix B, and the need for further research in this area is discussed in Chapter IV.

Dental auxiliary personnel were omitted from explicit consideration in the analysis because their levels of employment are determined by the economic decisions of dentists. The level of employment of auxiliary personnel is not an independent variable. For a given state of technology, a given number of dentists can vary the amount of services they provide by varying the number of auxiliaries they employ as well as by varying their own hours of work and amount of capital equipment they use. Consequently, interpretation of the model employed to project the supply of services assumes that auxiliaries are available as dentists wish to hire them. The implications of this assumption will be discussed in detail in Chapter III.

The last step of determining the requirements for dentists based on the projected demand for services was to calculate the number of dentists that will be required to make the quantity of dental services supplied equal to the projected quantity demanded as the dental market develops

along the long-run trend which has been followed in the past. The required number of dentists thus calculated is given in Table 1, columns 4 and 6. The total stock of dentists shown in column 2 of Table 1 is projected on the basis of existing facilities and enrollment levels and additions to capacity and enrollment that are now being planned and that will take place before 1980. The annual projected number of graduates for 1980-1990 and the corresponding total stock of dentists are shown in Table 2.

TABLE 1: Projected Requirements for Dentists and Projected Total Stock of Dentists 1980, 1985, and 1990

| Year | Estimated Total Stock of Dentists | ALTERNATIVE I | | ALTERNATIVE II | |
|---|---|---|---|---|---|
| | | Prepayment (Percent of Total Population) | Total Stock of Dentists Required | Prepayment (Percent of Total Population) | Total Stock of Dentists Required |
| 1980 | 142,111 | 26.9 | 148,300 | 26.9 | 148,300 |
| 1985 | 157,447 | 36.7 | 160,900 | 40.0 | 162,700 |
| 1990 | 172,333 | 43.3 | 170,200 | 50.0 | 172,200 |

TABLE 2: Projected Number of Dental Graduates and Total Stock of Dentists 1980-1990

| Year | Number of New Graduates | Total Stock of Dentists |
|---|---|---|
| 1980 | 5,210 | 142,111 |
| 1981 | 5,380 | 145,157 |
| 1982 | 5,460 | 148,261 |
| 1983 | 5,460 | 151,355 |
| 1984 | 5,460 | 154,408 |
| 1985 | 5,460 | 157,447 |
| 1986 | 5,460 | 160,466 |
| 1987 | 5,460 | 163,473 |
| 1988 | 5,460 | 166,457 |
| 1989 | 5,460 | 169,417 |
| 1990 | 5,460 | 172,333 |

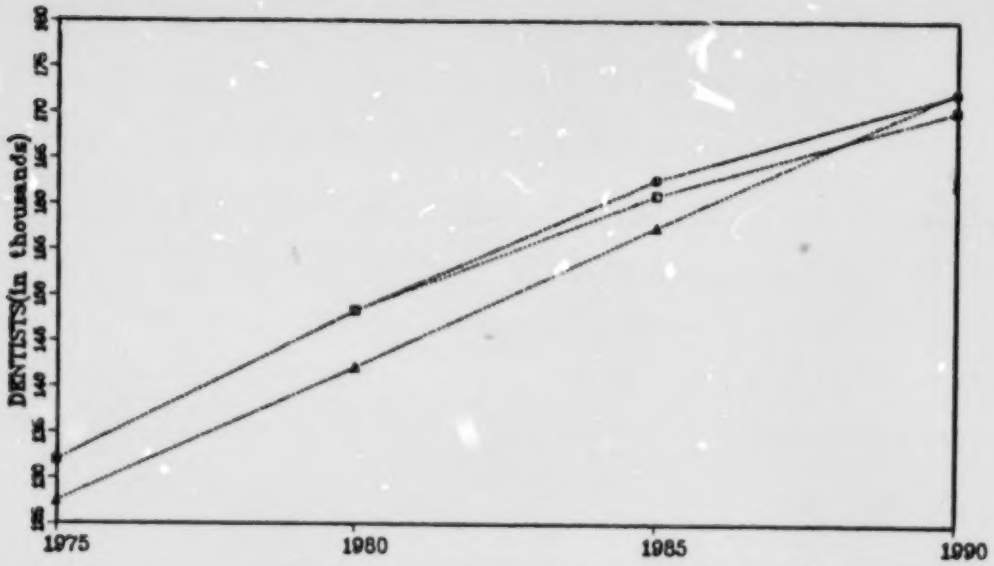
The required number of dentists is projected in terms of the total stock of dentists rather than the number of "active" dentists as the Division has done in the past. The reason for this is that the number of "active" dentists is a variable whose magnitude at any given time is a function of the aggregate level of economic activity, which makes the "active" number of dentists a short-run concept. Since these projections focus on the long-run, and on those variables which are most relevant from the viewpoint of manpower policy, the total stock of dentists is the appropriate variable for the projections of supply and requirements.

A graphic comparison of the projected number of dentists and requirements for dentists is presented in Figure I. As one can see in Figure I, a slight "shortage" of dentists is projected to prevail until shortly after 1985 when the rate of growth of demand for dental services is expected to decline somewhat. This decline is due to an anticipated leveling-off of the growth of dental insurance coverage in the private sector. Figure II graphically depicts the two projected time paths of the growth of insurance coverage. A comparison of Figure I and II reveals the correspondence of the leveling-off of insurance growth and the decline in the rate of increase in the required number of dentists. According to the economic analysis reported in Appendix A, the economic implications of the slight "shortage" of dentists and the subsequent projected surplus are not serious. For, under the projected conditions, the prices of dental services are not expected to rise at a rate significantly higher than that of the general price level. This is due both

FIGURE I

## REQUIREMENTS FOR AND NUMBER OF DENTISTS

FOR 1975 - 1990

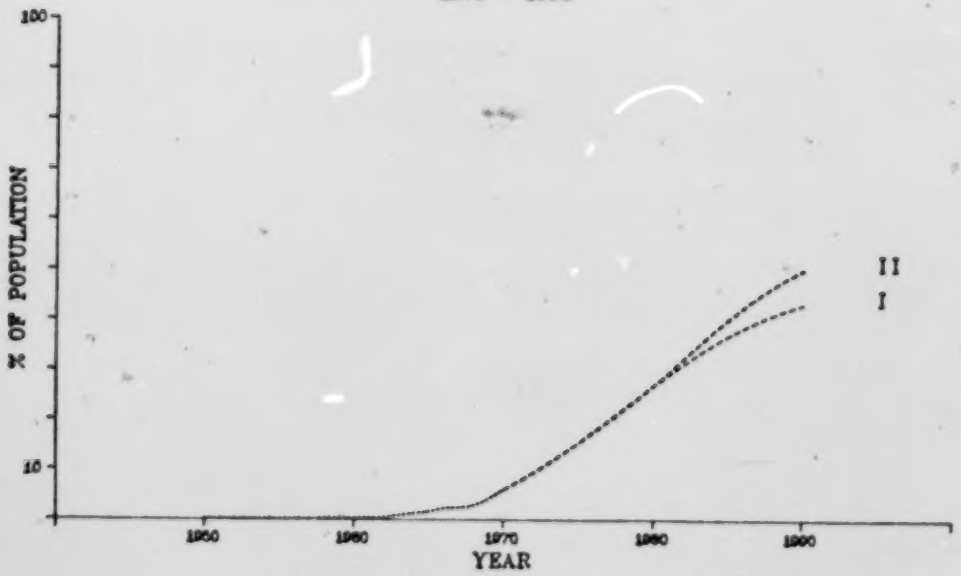



□ = REQUIREMENTS WHEN DENTAL PREPAYMENT COVERS FROM 15% TO 43% OF THE POPULATION
○ = REQUIREMENTS WHEN DENTAL PREPAYMENT COVERS FROM 15% TO 50% OF THE POPULATION
△ = PROJECTED NUMBER OF DENTISTS

FIGURE II

## ALTERNATIVE PROJECTIONS OF THE GROWTH OF DENTAL PREPAYMENT

1975 - 1990




I - DENTAL PREPAYMENT COVERS 43% OF THE POPULATION BY 1990
II - DENTAL PREPAYMENT COVERS 50% OF THE POPULATION BY 1990

to the fact that the health manpower legislation of the 1960's fortuitously anticipated the increase in demand and accelerated rate of increase in demand that occurred at the beginning of the 1970's with the increasing popularity of dental prepayment, and to the fact that the supply of dental services is very responsive to increases in demand.

The validity of these conclusions based on these projections is dependent on two major assumptions: 1) that the markets for dental services will remain competitive in the context of rapid growth of third party payment in the private sector; and 2) that the historical rate of technological progress will be sustained in the future. The latter assumption depends on the potential productivity increases that are available in the employment of expanded duty dental auxiliaries, as well as the willingness and ability (in the face of legal constraints of State practice acts) of dentists to employ them. This topic will be addressed in Chapter III.

Although in past projections developed by the Division of Dentistry a range of error or an upper and lower limit for the projected "requirements" have been provided, this will not be done here. The method used for the projections provide no basis for such calculations, for the projected values of the independent variables have no formal statistical properties upon which one can base calculations of error estimates. Moreover, the factors which may cause the actual courses of future events to deviate from their projected courses have not yet been considered. Our conclusions regarding the probable effects of these factors will be summarized in the next chapter.

## References for Chapter II


1. American Dental Association: "Can Americans Get the Dental Care They Need?," New York Times, October 5, 1975, Supplement, p.5.

2. Townsend, Henry: Investment in the Eighties (National Economic Projections Series Report 76-N-1), National Planning Association, 1976, p.17.

3. Bureau of the Census: Population Estimates and Projections, Series P-25, No. 541, February 1975.

Chapter III

## DEVELOPING TRENDS IN DENTISTRY: CONCLUSION

The previous chapter was devoted to discussing the factors determining the demand and supply of dental services and the projection of the historical trends of the variables into the future to derive the "requirements" for dentists. In this chapter, we discuss our conclusions about developing trends in dentistry and about the necessity of altering the requirements projections to anticipate the effects of developing or changing trends. A detailed discussion of the specific historical factors considered is presented in Appendix B.

The events and conditions underlying supply and demand will be discussed separately. To be considered under supply conditions are engineering advances and organizational changes in the delivery of dental services. To be considered under demand conditions are preventive dental health practices and third party payment.

Engineering advances that have had significant effects on the supply of dental services by increasing the productive capability of the Nation's stock of dentists include innovations in equipment, materials, and techniques as indicated in Appendix B.

The rate of gain in dental treatment production recognized as resulting from engineering innovation during the past 20 years has leveled off in recent years. Further, the engineering improvements in

dental practice technology that are in development at this time are thought not likely to provide large gains in dentists' productive capability in the present decade. The diminished rate of technological advance resulting from a slowed rate of engineering innovation has been largely supplanted by recent advances in the organization of dental office practice, especially those manifested by the use of auxiliaries. The potential for further increasing the output capability of dentistry through the use of expanded function auxiliaries is thought to be great. It is most likely that the greatest potential for sustaining the rate of technological progress established in the past lies in this dimension. However, whether or not these gains will be realized in the future is dependent on a number of factors, the bases of which are primarily economic.

As discussed in Appendix A, the national demand for dental services is highly volatile with respect to fluctuations in the aggregate level of economic activity. While there are a number of issues involved, this fact may go far to explain the dental profession's current organized opposition toward the use of trained expanded-function dental auxiliaries and toward allowing the scope of their functions to be expanded even further when one recalls that the economy has just experienced a severe recession which is said to have precipitated a significant decrease in demand for dental services. Likewise, this fact provides substantial reason for predicting that, when the economy has returned to its normal

rate of growth and the demand for dental services picks up, the dental profession will relax its opposition to expanded duties for auxiliaries when it again becomes in its economic interest to do so.

In the face of increasing demand for dental services, how will the supply respond and what is the implication for the requirements for dentists? As reported in Appendix A, the supply of dental services is highly responsive to economic conditions in terms of the elasticity of supply with respect to the price of services. This implies that as demand changes, dentists have quite a bit of flexibility in changing their output of services. The information reviewed in Appendix B suggests that much of this flexibility can be accomplished through changes in the employment of dental auxiliaries. Consequently, it can be anticipated that the major response to increases in demand for dental services will be manifested in dentists' increased use of conventional auxiliaries. Moreover, when it appears to be in the dentists' best economic interest, a relaxation of restrictions on the scope of delegated functions can be expected with an increased demand for and employment of trained expanded-function dental auxiliaries.

We conclude that while no extraordinary engineering breakthroughs can be foreseen, there seems to be much potential for expanding output through organizational changes. The model used to project the supply of dental services assumes that these changes can and will be made as dentists find that it is to their economic advantage. Therefore, there is no compelling reason to revise the projection of the supply of dental services made in Chapter II.

Should the projection of demand be revised in the light of any developing trends that can be anticipated? As discussed in Appendix B, preventive measures utilizing fluorides have primarily benefited children and young adults. Because of the proven dental health benefits that will accrue as a result of community water fluoridation, we can expect a future reduction (of at least 50 percent among affected school-age children) in restorative dental care needs and demands. The benefits gained in the developmental years extend into the adult years, so it can be anticipated that restorative care needs will also be reduced for an increasing number of adults in the future. There is a maximum potential for the benefits of fluoridation to be extended to about 80 percent of the total U.S. population (all of those served by public water supplies).

There are a number of other decay-preventive programs for children being used or promoted, such as school mouthrinse programs or group topical fluoride applications in nonfluoridated areas, and school water supply fluoridation or tablet distribution where there is no public water supply. These programs are clearly effective within their inherent limitations. The duration of the preventive effects after the children leave the programs has not been specifically established, but is generally thought to be quite short. It therefore appears that the reduced need for restorative dental care gained through these programs will be evident only during the school years and shortly thereafter.

Although the beneficial effects of fluoride are unambiguous for children and young adults, there is far less certainty about the effect on dental care needs and demands that will be produced by extending the

useful life of more of the natural teeth in older adults. This developing trend will assuredly result in a greater number of adults who will be enjoying the obvious advantages of natural teeth, but will also be potentially subject to periodontal disease and at risk to further incidence and progression of tooth decay. The prevention of periodontal disease is dependent primarily upon personal oral hygiene habits of the individual and regular periodic attention of the dentist. It may be that as the need for restorative work declines among children and younger adults, the pedodontist and general dentist will find their time requirements reduced for that age bracket, while the periodontist, endodontist, and general dentist will find their services more in demand by longer-lived and more toothsome adults. Until more explicit information on adults is developed, predicting the total effect of universal optimal fluoridation and other preventive measures on dental manpower requirements will remain an uncertain venture. Consequently, we conclude that a revision of the demand projection made in Chapter II is inappropriate at this time on account of anticipated changes or improvements in dental disease prevention.

It was mentioned in Chapter II that the validity of the projections reviewed there rested on the assumption, among others, that the markets for dental services will remain competitive as the proportion of the population covered by dental benefits increases because the economic model used to make the projections, discussed in Appendix A, is based on the assumption of market clearing through price adjustment. While this

assumption is quite tenable for past and present levels of dental prepayment coverage in the population, its validity will grow increasingly suspect if, as a higher and higher proportion of the population is covered by dental prepayment, the price of dental services loses its function as the mechanism which equilibrates the supply and the demand for dental services. The fact that price does not serve this function in the market for hospital services, where 80 percent of the population has some type of "insurance" coverage, is seen to be a major contributor to the runaway inflation in that industry. The market for physician's services suffers from the same problem, but to a lesser extent. If, as the extent of dental prepayment expands in the future, the role of price in the market for dental services is eroded in the same way that it has been in the markets for physician's services and for hospital services, then the future state of the dental service market will grow more and more uncertain and less and less predictable. At the present time, however, it is not possible to anticipate the extent to which the function that price currently plays in the dental care market may be eroded by the future development of dental prepayment.

Chapter IV

## ADDITIONAL RESEARCH NEEDED

It is apparent that in several ways, the projections of dental personnel requirements presented and discussed in the preceding chapters leave something to be desired. The deficiencies in the projections fall generally into two categories: deficiencies owing to lack of information and deficiencies of technique. These will be discussed in this final chapter in terms of the implications for further research that should be carried out to improve the determination of future requirements for dental personnel.

The problematic area of most concern is that of dental prepayment. The possible range of growth of dental coverage is so wide that, without additional information to narrow the range of uncertainty, it is difficult to predict with precision whether or not the current and predicted rate of output of dentists will be adequate to meet the demand for dental services. Research must therefore be undertaken to determine if a systematic pattern has characterized the historical spread of dental coverage and, if so, to what predictable variables the growth of dental coverage is related. In particular, it was noted that dental benefits are intimately associated with fringe benefits gained through collective bargaining. This suggests a study of the relation of dental coverage in collective bargaining agreements to industry characteristics. If such a

relation can be established, then the future course of dental benefits can be predicted more accurately by ranking industries according to the likelihood of their incorporating dental benefits in future collective bargaining agreements.

A second major area of concern is the absence of knowledge about the future long-term dental health benefits of the growing use of fluoridated water. While the immediate results of fluoridation are apparent in a decreased incidence of caries among children and young adults, the complete long-term results have yet to evidence themselves on a large scale. One such result among older adults is the desired longer retention of more of their natural teeth, but this might result in a larger population of adults subject to periodontal disease and continued progression of caries. Research is needed to develop information on the dental care needs and demands of older adults who retain their natural teeth, in comparison with those not benefited by fluoridation who have probably lost more of their teeth because of dental caries.

A third major area of uncertainty is that of the effect of dental hygienists on the supply of dental services. Although hygienists work under the supervision of dentists, they usually work within the context of the office practice such that their aggregate output is independent of the number of dentists. Ideally, hygienists would be included as an explicit variable in the projection model. To include hygienists as an argument in the supply function used in projecting dental manpower

requirements, information is needed on the total number of hygienists, their availability to the labor force, and their pattern of labor force participation. Much of this information is not yet available.

The last major area of uncertainty lies in the anticipated growth in demand for expanded function dental auxiliaries (EFDA's). Studies of dental practice production functions have shown that the employment of EFDA's can significantly increase the output of the private practice. The Government has encouraged and promoted the training and utilization of EFDA's in its manpower policies. But although the technological feasibility of EFDA utilization has been shown in many research and demonstration projects, little research has been focused on the more important issue of the demand for EFDA's, which is the major consideration underlying their employment and utilization by private practitioners. It is the dentist's assessment of the economic feasibility of utilizing EFDA's that ultimately determines their employment. Yet, little research has been focused on the factors underlying the demand for EFDA's which must be understood if their rates of employment and utilization are to be predicted.

With respect to problems of technique, the major problem of the projection approach to predicting future personnel requirements is that the simple approach used in this paper, although far more sophisticated than the approaches used previously, does not facilitate taking into account much of the information we have about the demand and supply of

dental services. A more elaborate and detailed model is needed that can take into account more of the information about the cause-and-effect relationships generating the variables of interest. Such a model is now under development by the Division of Dentistry and will be ready for testing by the end of 1977 to produce short-run and long-range forecasts of activity in the national dental sector. The model being developed is an aggregate economic model whose structure will incorporate much more information into forecasts of supply and demand than can be accommodated in making simple projections.

The current projections and future forecasts to be generated by the economic model under development are focused at the aggregate, or national, level. Hence, they do not serve the need for information about the distributional issues surrounding manpower supply and requirements. The Division of Dentistry is, therefore, developing a method of disaggregating the national projections and forecasts to the State level so that the distributional implications of the projections and forecasts can be examined. But while the macro-approaches lend themselves to some disaggregation, such disaggregation rapidly compromises the validity of macro-based methods. As emphasis on subsets of the national population and on smaller and smaller geographical areas increases, the need for a micro-based approach to determining manpower requirements will grow. In anticipation of this growing need the Division of Dentistry has programmed the development of a micro-simulation model of dental personnel requirements. The technical details of this model are available from the Division.

Appendix A

## THE DEMAND AND SUPPLY OF DENTAL SERVICES

The determination of the consumption, production, and prices of dental care is generally regarded as a market phenomenon to a much greater degree than is the case with medical or hospital care. While this greatly facilitates efforts to estimate the supply and demand relationships that underly the generation of observed prices and quantities of dental services, relatively few attempts to estimate these relationships have been pursued.[1] This Appendix reports the results of an effort to estimate the national aggregate demand and supply functions for dental services with time-series data. After the model and estimates are discussed, the time-series results are compared with results obtained by P. Feldstein [3] from pooled cross-section/time series data using a similar simultaneous-equation approach. The Appendix concludes with a discussion of some of the policy implications of the estimated relationships.

The purpose of the estimation was to provide a means of projecting the demand and supply of dental services into the future. Of primary interest on the demand side was the growth of demand in response to future growth in the population, income, and in the proportion of the population covered by dental insurance. On the supply side, the primary interest was in the expansion of supply facilitated by technological change in the practice of dentistry, and in the effect of growth in the stock of dentists on the supply of services. The model employed was the simultaneous supply-demand system (1)-(4):

$$q_{ut} = a_o + a_1 p_t + a_2 Y_{ut} \quad (1)$$

$$q_{it} = a_3 \quad (2)$$

$$q_{st} = b_o + b_1 p_t + b_2 t \quad (3)$$

$$Q_{dt} = N_{ut} q_{ut} + N_{it} q_{it}$$

$$Q_{st} = D_t q_{st}$$

$$Q_{dt} = Q_{st} \quad (4)$$

where:

$Q_{dt}$ and $Q_{st}$ are the quantity of dental services demanded and supplied, respectively, measured by the total real annual expenditures on dental services in the U.S.;

$q_{st}$ is the quantity of dental services supplied per dentist in year t;

$D_t$ is the number of dentists in year t;

$q_{ut}$ and $q_{it}$ are the per capita quantities demanded by the uninsured and insured population, respectively, in year t;

$N_{ut}$ and $N_{it}$ are the number of people, respectively, in the uninsured and insured population in year t;

$p_t$ is the average price in year t of a unit of dental service, measured by the dental component of the Consumer Price Index relative to the general price level as measured by the Consumer Price Index;

$y_{ut}$ is real annual personal income per capita of the uninsured in year t.

The data used to estimate the system (1)-(4) are annual time series covering the period 1950-1970. The inclusion of t as an argument in the supply function (3) is intended to isolate the systematic shifts in the supply function resulting from technological progress.

The definitions of $Q_{dt}$ and $Q_{st}$ are employed to derive the aggregate demand and supply functions (4a) and (4b):

$$Q_{dt} = a_o N_t(1-I_t) + a_1 p_t N_t(1-I_t) + a_2 Y_t(1-I_t) + a_3 N_t I_t \qquad (4a)$$

$$Q_{st} = b_o D_t + b_1 p_t D_t + b_2 t D_t \qquad (4b)$$

where $N_t$ is the size of the population in year t, $I_t$ is the proportion of the population covered by dental "insurance," and $Y_t$ is total real personal income in year t.

Equations (4a) and (4b) are employed to estimate the parameters of equations (1)-(3). Deriving the aggregate demand and supply functions in this way is intended to preserve the manifestations of the distinct behavior of the groups of individuals on the the demand side of the market, whereas the distinct aspects of their behavior might be obscured or confounded in a demand equation that is specified directly in aggregate terms.[2]

The specification of demand function (2) reflects the assumption that dental prepayment coverage was not yet extensive enough at any time during the period of observation to significantly alter the price determination mechanism assumed to equilibrate the system (1)-(4). Under universal third-party payment, price would not perform the equilibrating function assumed in system (1)-(4). However, it is safe to

assume that as long as the proportion of the population covered by dental prepayment is small, the market does function to determine the price, and dentists charge the same price to everyone. An analagous situation is that of food stamps; the market determines the price of groceries that is paid by everyone, because the proportion of total demand subsidized via food stamps is so small that sellers cannot discriminate among buyers. The subsidization of a small portion of demand simply displaces the aggregate demand function slightly, as is assumed in the specification of equation (4a). The proportion of the population covered by dental prepayment ranged from 0.002 in 1950 to 0.06 in 1970.

A few additional comments about the specification of model (1)-(4) are warranted. First, it has been a frequent practice in similar studies to include measures of inputs (i.e., number of auxiliaries used, time worked by the practititioner, etc.) in the supply function; see, in particular, [2] and [4, p. 61]. But although inputs are generally endogenous variables in such systems -- i.e., their magnitudes are jointly determined with price and quantity--no attempts have been made to include the appropriate equations to determine input. Nor have the measures of the variables been adjusted to remove from the disturbance term of the supply function the correlation with these extra endogenous variables. Failure to do so could lead to serious biases in the estimates of the parameters of the function. The specification of the model (1)-(4), however, avoids these difficulties by viewing the determination of quantity supplied at a higher level of abstraction. The model abstracts

from the explicit behavioral and economic phenomena determining input levels and other endogenous variables. The model attains this level of abstraction by assuming that the number of dentists and the state of technology determine the position of the supply function in the price-quantity plane, and by assuming that equilibration with demand is accomplished by movements along the supply function afforded by dentists implicitly choosing the levels of technology and inputs to employ.

A second set of considerations explicitly included in some other studies, but not in this one, are so-called demographic characteristics of the population which, having changed through time, could have systematically affected the demand for dental services. The fact is, however, that on the aggregate level, the distribution of most definable and measurable demographic characteristics of the population have not changed very much. For example, the age distribution of the populatio has been essentially stable over the period of observation, with only slight changes in the mean and median age. In any case, the important changes that have occurred over time are those that have to do with the general preferences of the population. Not only are general preferences probably changing in direct relation to the passage of time, but population cohorts with successively higher propensities to consume dental care are being introduced into the population each year. The statistical problem is to separate the time effect that would be evident if the population were to remain of static size from the effect of introducing new cohorts with higher awareness and emphasis on oral health than their

predecessors. Unfortunately, this cannot be done in the present context, for the growth of the population has been closely related to the time variable over the period of observation; thus the separate effects of the particular character of population growth and the time-related change in preferences and taste cannot be isolated statistically.

Equations (4a) and (4b) were estimated with two-stage least squares by substituting for the actual value of $p_t$ the regression of $p_t$ on the exogenous variables. The measures of $Q_t$, $p_t$, $Y_t$, and $D_t$ used in the analysis were relative to 1950; that is, the series of these variables were indices computed with the respective values of the variables in 1950 as the base. The estimates of the coefficients are shown in Table 3, together with their estimated standard errors; average elasticities computed at the means of the observed variables are also reported in Table 3.

Table 3: Estimated Parameters of Supply and Demand Functions for Dental Services

| Coefficient | Estimate | Standard Error | Elasticity* |
|---|---|---|---|
| $a_0$ | 4.74 | 1.42 | ... |
| $a_1$ | -5.53 | 1.41 | -4.40 |
| $a_2$ | 1.69 | 0.15 | 1.43 |
| $a_3$ | 4.50 | 2.34 | ... |
| $b_0$ | -4.34 | 0.65 | ... |
| $b_1$ | 2.52 | 0.70 | 1.54 |
| $b_2$ | 0.057 | 0.002 | 2.15 |

*For every one percent increase in the uninsured population, the total demand of the uninsured population increased by an average of 1.27 percent; for every one percent increase in the number of dentists, the aggregate supply of dental services increased by an average of 0.97 percent.

In examining these estimates, it is interesting to note the coincidence of the estimated constant terms of demand equations (1) and (2). As price goes toward zero in equation (1) (and as the importance of income can be assumed to also approach zero), per capita quantity demanded by the uninsured population will evidently converge to that of the insured population. But while the logical consistency of the estimated coefficients is appealing, it is unclear if this is evidence that actual behavior will conform to the function beyond the observed range of price variation. One should exercise caution in basing speculation about the effects of reducing prices (for example, in contemplating the possible effects of national health insurance on demand) on such statistical results.

The estimated price elasticity of demand indicates that quantity demanded is quite volatile with respect to changes in the price of dental services. That the demand for dental care is price-elastic has been widely recognized. The sensitivity of demand to changes in price has been exemplified by the fact that while the cost of operating a dental practice increased more than 200 percent between 1967 and 1975, dental fees have increased only 62 percent [1]. That dentists have not been able to "keep up" with cost is certainly indicative of a high elasticity of demand for their services. However, one should infer with caution the implications of the large estimated price elasticity of demand. While it can be assumed that increases in price will stimulate an exodus of consumers from the market, it is contrary to ordinary notions of the nature of the demand for dental services to assume that a decrease in price will produce an equal but opposite response in quantity demanded. It is commonly held that going to the dentist is of the nature of a habit that must be developed or cultivated over a long period of time. Thus, it might be easier to drive people out of the market with a price increase than to attract them into the market with a decrease in price, at least in the short run. No definitive research has yet been focused on this popular notion; however, studies of consumer behavior under newly-adopted dental prepayment plans will hopefully clarify the issue in the future.

Another remarkable aspect of the statistical results is the estimated effect of "technological change" on the supply of dental services over time. Over the period of observation technological progress has,

according to the estimate, evidently served to increase the supply of services by an average of 2-3/4 percent per year.[3] If one looks at the history of technological innovation in dentistry over the period, specific phenomena that account for much of the increase in supply are easily discernable. Rapid adoption of the high-speed (30,000 to 99,999 rpm) dental handpiece and the ultra-speed (100,000 and higher rpm) handpiece in the several years following their commercial introduction in 1955 has been credited by many observers as a major innovation leading to a large increase in efficiency.

But the introduction of the high speed handpiece with its coolant water spray also produced a need for large volume evacuation of fluids and solids from the mouths of patients. This need led to the introduction of high-volume suction system for oral evacuation in about 1960, which eliminated the frequent interruption of the dentist's work required to let the patient rinse out his mouth using a cup of water and the chairside cuspidor. The availability of suction equipment allowed a chairside assistant to eliminate all the rinsing time by continually evacuating the patient's mouth while the dentist continued to work or pause only briefly. This practice rapidly led to the development and implementation of four-handed sit-down dentistry in which the dentist works in a sitting position over the patient while being assisted by a dental auxiliary.

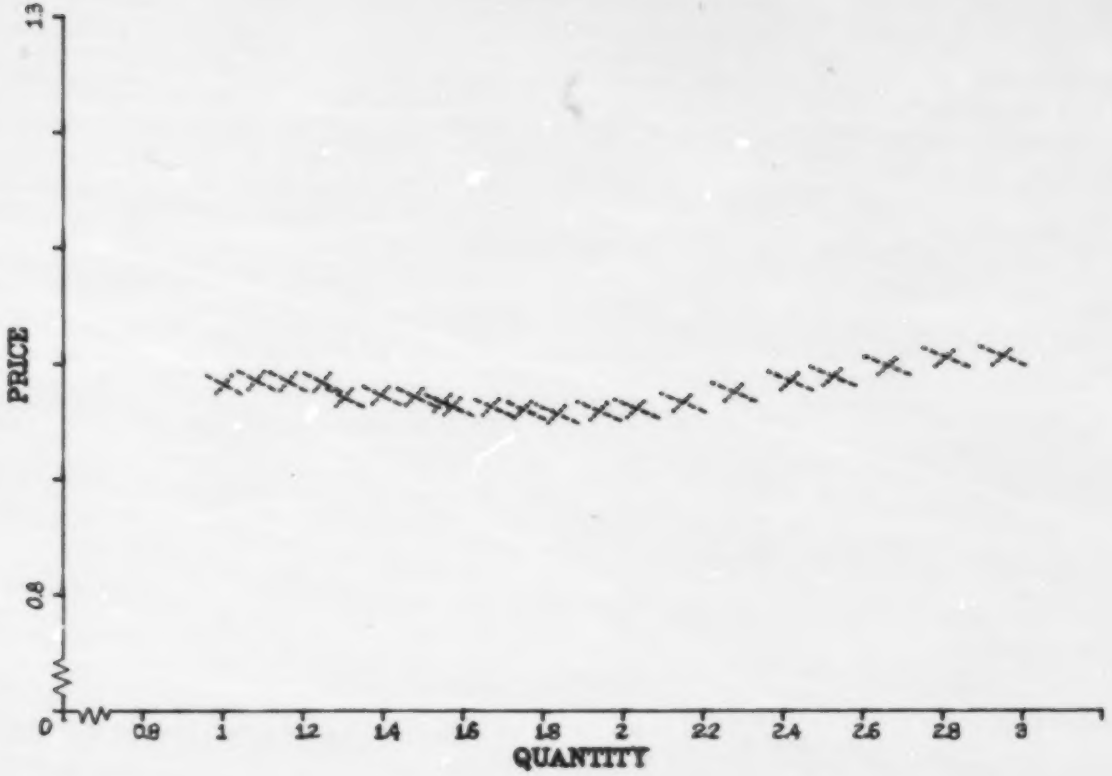
Utilization of an extra pair of hands provided by a trained assistant in four-handed sit-down dentistry has, for the last several years, been recognized as the most efficient method of practicing dentistry. At the present time, some dentists are beginning to delegate more and more functions to auxiliary personnel, and a few are adopting organizational systems in which expanded-function auxiliaries work under the supervision of a dentist and perform many intra-oral procedures. At the same time, the employment of dental hygienists who, under the general supervision of the dentist perform their duties more or less independently, has been expanding rapidly. All of these developments have had the result of allowing a given stock of dentists to produce more and more services, as manifested by the outward shift of the supply function through time.

The effect that these technological innovations have had on the market for dental services is apparent in Figure III, which shows the annual positions of the estimated supply and demand curves in the price-quantity plane over the period of observation 1950-1970. During the decade of the 1950's the annual changes in the demand for services were erratic, but on the average, demand expanded at a constant rate. As the decade of the 1960's began, however, demand started to increase at an accelerated pace. Yet, the supply was able to keep up and temper the rate of increase in prices that otherwise might have occurred. This rapid expansion of supply was made possible, in large part, by the availability of the technologies discussed above which allowed dentists to expand capacity in response to the rapidly increasing demand.

FIGURE III

## ESTIMATED DEMAND AND SUPPLY OF DENTAL SERVICES

FOR 1950 – 1970



Overall, the statistical results indicate that the market, on both the demand and supply sides, is highly sensitive to economic factors--price and income. The sensitivity of the market to the over all level of economic activity is quite apparent in Figure III. The results can be compared with those reported by P. Feldstein from an analysis of pooled cross-section time-series data [3, p. 144]. First, however, it is important to note that Feldstein's model omitted insurance from the demand function and time from the supply function. Second, Feldstein's dependent variable was patient visits rather than real expenditure on dental service. Third, Feldstein's estimating equations were expressed in per capita terms; while it is difficult to envision a market clearing on a per capita basis, his results do appear reasonable. Fourth, the cross-section units of analysis used by Feldstein were the seven regions of the U.S. defined by the American Dental Association for reporting the results of surveys of dentists.

The major difference between the results of the time-series analysis reported above and of Feldstein's analysis is evident in the estimates of the price elasticities of demand and supply. The price elasticity of demand implied by the estimate above is -4.4 while that reported by Feldstein was -1.43; the price elasticity of supply implied by the model above is 1.54, while that reported by Feldstein was 0.29. The differences in the results cannot be attributed to imprecision or to lack of efficiency in the experimental designs, for both sets of estimated coefficients are "highly" significant statistically. To reconcile the differences in the two sets of estimates, one must view the two models from the perspective of a more complete model to assess the specification problems that may be affecting their results.

Consider, therefore, the cross-section relation in which the supply of dental services in a geographical area is a function of the number of dentists in the area. The question from the viewpoint of specification is whether or not the number of dentists is exogenous or endogenous. If the number of dentists is endogenous, then the model must include additional relations giving the total number of dentists and explaining their distribution across the geographical areas. In particular, if one views the time-series process generating the cross-section observations, it cannot be concluded that the number of dentists observed in each area is exogenous unless each of the areas are totally isolated entities. If the areas are not totally isolated and independent, then, given the total number of dentists, a mechanism distributing the total number of dentists among the areas must be explicitly included in the model.

The reasoning above suggests that perhaps Feldstein's mixed cross-section/time-series model may be misspecified because the number of dentists at each point in time is not independent of the number of dentists in the other areas, and because the relation between them is omitted from his model. In particular, the numbers of dentists and the prices in each area are probably mutually and jointly determined over the long period of time between Feldstein's observations, which is three years; consequently, the estimates of the parameters of his model could be somewhat confounded. The pure time-series aggregate model, however, is not affected by distributional considerations and can stand alone as a complete model determining prices and quantities on a national basis.

The importance of the differences in the two sets of estimates lies in their implications for policy. In particular, consider the different implications of the alternative estimates of the price elasticity of supply. Feldstein's model and data suggest that the supply of dental services is highly inelastic with respect to price. Thus the implication of this estimate is that a sudden increase in the demand for dental services precipitated by, say, the adoption of a national dental insurance plan, would result in a large increase in price and a relatively small increase in production and consumption of dental services in the short run. On the other hand, the estimate of the price elasticity of supply presented in this Appendix suggests that such an increase in demand would be accommodated in the short run by a responsive expansion of output and a relatively smaller increase in price. Consequently, the two estimates have different implications for the extent of long-range planning required to accommodate the adoption of national health insurance, if the objective of such planning is to minimize dental price inflation.

The implications of the two models for the long-run effect on the supply of services of increasing the number of dentists are essentially the same: both estimates of the elasticity of supply with respect to the number of dentists are about unitary. Thus, both models agree that policy efforts resulting in an expansion of the stock of dentists should elicit an equa-proportionate increase in the supply of services.

Since much of the productive capacity as well as the output of the education system for dental personnel is now subject to discretionary action in the public sector, the question of how many dentists will be "needed" to meet future manpower requirements is often asked by policy-makers and administrators. This question can be addressed within the framework of the model presented in this paper in a straightforward way. For, given the projected levels of the population, dental prepayment coverage, and national income, one can simply solve for the number of dentists required to equilibrate supply with the projected demand. All one needs to perform this calculation is a welfare criterion for choosing which price and quantity the solution should satisfy. An obvious and practical criterion is suggested by an examination of the historical performance of the market for dental services which can be undertaken with reference to Figure III. The time path of the equilibrium locus of demand and supply illustrated in Figure III indicates that the market has historically generated a stable relation between the nominal price of dental services and movements in the general price level; the market has adjusted over time so that the real price of dental services has remained essentially constant over the 20-year period. In view of the historical stability of this relationship, it would seem appropriate for policymakers to aim at maintaining the long run secular balance between the nominal price of dental services and the general price level if their objective is to tailor the stock of dentists to meet projected future demands for dental services.

From an alternative perspective, one may employ the estimated supply and demand relationships to project the future states of the market for dental services, and decline to enter the debate over whether or not the results have appealing welfare implications. This is the approach that will be pursued in the remainder of this Appendix.

The demand and supply of dental services were projected for the years 1975, 1980, 1985, and 1990 utilizing projections of the exogenous variables which are available from various sources. The projections of economic growth are those of the National Planning Association (NPA) [5, p. 17]. Using a long-range econometric model, the NPA has forecast that the economy will grow at an average real rate of 3.9 percent per year through 1985. This figure was assumed to prevail through 1990. The projection of population growth employed in the dental service demand projection was the Census Bureau's Series II which is generally regarded as the most representative of current trends. Series II assumes that the fertility rate will gradually increase from the current rate of 1.8 to a rate of 2.1 in the year 2025 [6].

The projections of the growth in the stock of dentists and of the growth of dental "insurance" coverage are discussed in the text. The number of dentists expected to graduate each year is projected by the Division of Dentistry on the basis of the current number of dental schools and present and planned rates of graduation of dentists [7]. The projections of dental insurance coverage are explained in Appendix B; it was projected that dental insurance coverage in the private sector

FIGURE IV

## PROJECTED DEMAND AND SUPPLY OF DENTAL SERVICE

FOR 1975,1980,1985,1990

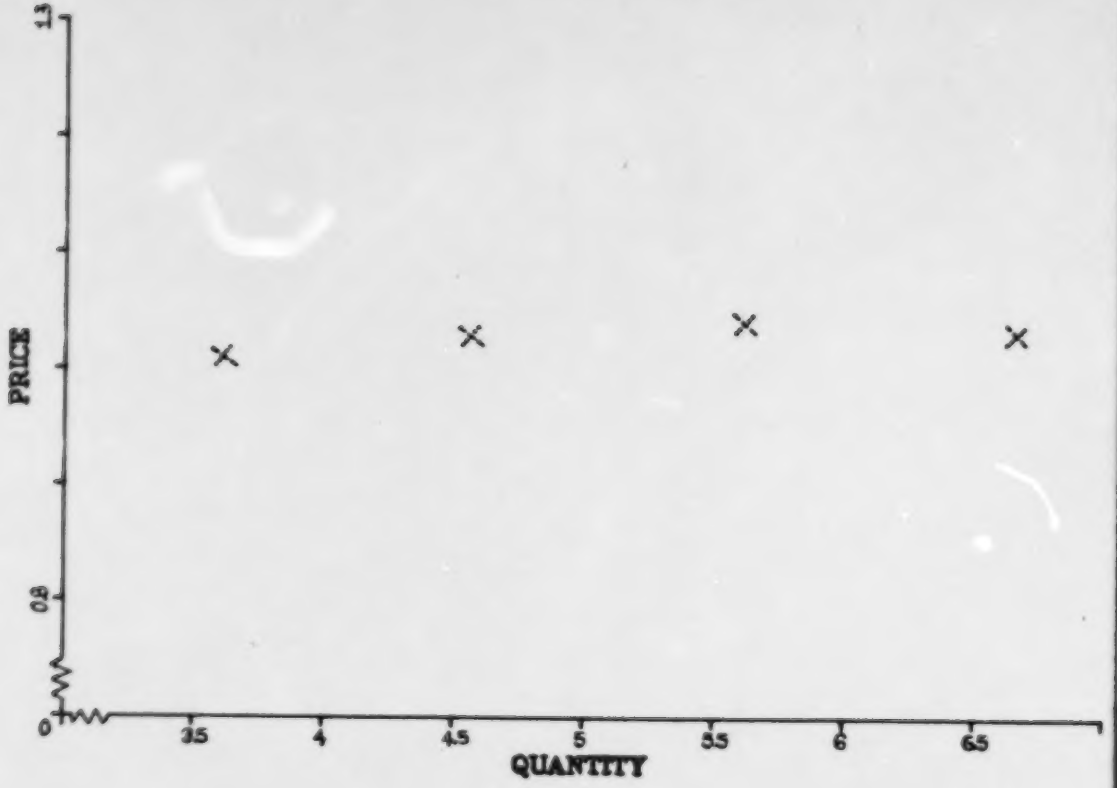
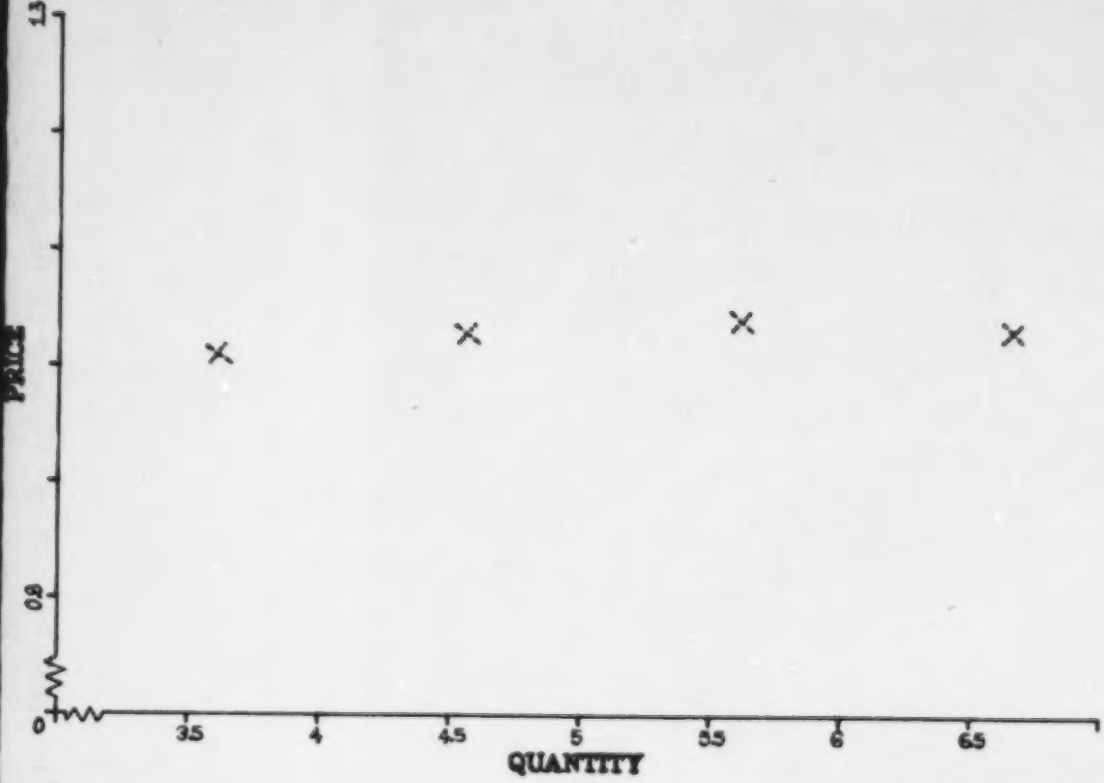


FIGURE IV

# PROJECTED DEMAND AND SUPPLY OF DENTAL SERVICES

FOR 1975,1980,1985,1990



will grow at a rate of 17 percent per year through 1980, and may extend to 50 percent of the population by 1990. The projections do not, however, take national health insurance into account. Although it seems probable that some type of national health insurance scheme will be enacted before the end of the period in question, both the timing of its appearance and the extent of dental coverage to be included, if any, is unpredictable.

The positions of the supply and demand functions for dental services projected on the basis of the assumptions outlined above are shown in Figure IV. The projected path of supply and demand equilibria shows only a very slight increase in the real price of dental service over the period; given the projected increases in the stock of dentists, demand may increase by a slightly greater amount than supply to produce a 6 percent increase in the price over the 15 years covered by the projections. Thus the health manpower legislation of the mid-1960's that produced an acceleration in the output of dentists in the early 1970's seems to have anticipated subsequent developments on the demand side of the market very well, especially the increasing prevalence of dental prepayment in the private sector. It would seem that the market for dental services can look forward to a continuation of the relative degree of economic stability that it has enjoyed in the past as long as the aggregate level of economic activity follows a stable trend.

## Footnotes For Appendix A

1. The difficulty of estimating supply and demand relationships for health services is perhaps most vividly illustrated by M. Feldstein's attempt to do so for physician's services [2]. After running a large number of regressions using aggregate time-series data, Feldstein was unable to report satisfactory results, and concluded that the market must be in permanent disequilibrium.

2. The direct specification

$$Q_{dt} = A_o + A_1 p_t + A_2 Y_t + A_3 N_t + A_4 I_t$$
$$Q_{st} = B_o + B_1 p_t + B_2 D_t + B_3 t$$

yielded incredibly large estimates of the price elasticity of demand (-8.5), and the elasticity of demand with respect to the population (5.91). The alternative specification reported in the text seems to give more "reasonable" results.

3. Over the 20-year period, the supply function shifted 71 percent due to technological change, which is a compound annual rate of about 2-3/4 percent.

References For Appendix A


1. American Dental Association, Bureau of Economic Research and Statistics: "Dentists Fees and Inflation," Journal of The American Dental Association 93 (July 1976), 129-33.

2. Feldstein, Martin S.: "The Rising Price of Physician's Services," The Review of Economics and Statistics LII (May, 1970), 121-33.

3. Feldstein, Paul J.: Financing Dental Care: An Economic Analysis, Lexington Books, 1973.

4. Maurizi, Alex R.: Public Policy and the Dental Care Market, American Enterprise Institute for Policy Research, 1975.

5. Townsend, Henry: Investment in the Eighties (National Economic Projections Series Report 76-N-1), National Planning Association, 1976.

6. U.S. Bureau of the Census: Population Estimates and Projections, Series p-25, No. 541, (February 1975).

7. U.S. Department of Health, Education, and Welfare, Bureau of Health Manpower, Division of Dentistry: Dental Manpower Fact Book, 1976 (mimeographed).

Appendix B

## PAST AND DEVELOPING TRENDS IN DENTISTRY

Chapter II was devoted to discussing the factors determining the demand and supply of dental services and the projection of the historical trends of the variables into the future to derive the "requirements" for dentists. In this Appendix, the historical events underlying changes in the demand and supply relationships are examined. This examination is undertaken in order to consider whether or not the estimates of the parameters of the supply and demand functions or the projections of trends should be adjusted in anticipation of significant changes in those parameters or trends.

The events and conditions underlying supply and demand will be dealt with separately in this Appendix. To be considered under supply conditions are engineering advances and organizational changes in the delivery of dental services. The factors comprising these changes, which are encompassed in the term "technological advances" discussed in chapter III, will be examined to determine if the same patterns of technological advance can be projected into the future. To be considered under demand conditions are advances and changes in disease-preventive dental health practices and third party payment.

## Engineering Advances

Engineering advances--innovations in equipment, materials and techniques--have had considerable effect on the supply of dental services in the health-care system by increasing the production capability of dentists. The most relevant engineering advances will be briefly discussed below. It should be noted that the interrelationships between the various engineering changes, as well as with the organizational changes, make it impossible to attribute an independent increase in production capability to each of the advances discussed.

In 1955 the high-speed dental handpiece was made commercially available. The dental handpiece is the instrument used to remove decayed tissue from the tooth and to prepare and shape the tooth for insertion of the restoration. The rapid adoption of the high-speed (30,000 to 99,999 rpm) dental handpiece and the ultra-speed (100,000 and higher rpm) handpiece in several years following their commercial introduction has been credited by many observers with most of a concurrent increase in dental production [28] [2] [4] [11]. In their 1962 survey report [4], the American Dental Trade Association (ADTA) reported some specific estimates of these increases. ADTA calculations showed that dentists using the newer handpieces were able to complete 136 percent more amalgam restorations, 91 percent more acrylic restorations and 73 percent more silicate restorations than when using low-speed (25,000 rpm or lower) handpieces. Chairside time required for completion

of other procedures involving cutting of hard tissue was also reduced. The ADTA reported that 80 percent of U.S. dentists had adopted the new equipment by 1962 and that approximately 95 percent of U.S. dentists were using the higher-speed handpiece by 1966 [4] [16].

For many years, before the introduction of the high-volume suction evacuator in the early 1960's, the intra-oral preparative and restorative work of the dentist was frequently interrupted by the need for the patient to rinse out his mouth using the chairside cuspidor. The non-productive time used in rinsing, re-positioning the patient, and resuming the treatment was considerable. This became a major problem with the introduction of the high-speed dental handpiece which used a constant spray of water for cooling. The introduction of high-volume suction evacuators essentially eliminated the rinsing time. A chairside assistant was then able to maintain a constantly clear operating field, enabling the dentist to complete procedures without interruption for rinsing [24] [23].

The introduction of the new high-speed cutting equipment and oral evacuation equipment allowed the introduction of another engineering advance--the contour dental chair. Since the patient no longer was required to move about during the operative procedure to expectorate, the contour dental chair made it possible to position the patient for the maximum visibility and access. For the dentists and assistants this

provides for the more efficient delivery of equipment and instruments to the operating site and permits them to work in a seated position, resulting in reduced fatigue and improved efficiency while assuring maximum patient comfort.

It is apparent that there has been a close interrelationship and interdependence between these engineering changes and the organizational changes involving the use of trained dental auxiliaries.

Panoramic X-ray equipment, introduced in 1959, provides a radiograph of all the oral structures (soft tissue, teeth, bone and sinuses) on one film by a single exposure. The dentist's chairside time is reduced, as the simplicity of the exposure techniques both reduces the time required and makes possible the use of auxiliary personnel for performing full-mouth radiography. Presentations to the patient are faster as the single radiograph makes the structural relationships more clear and gains better patient attention. Pettit [3] has estimated that an experienced user can do in excess of 80 percent of all diagnosis from a panoramic film. A study at one school of dentistry [34] indicated a minimum professional time-saving of just over ten minutes per patient as compared with the conventional full-mouth method using multiple films, and some estimates of time saved were as high as 30 minutes per patient.

Panoramic radiography has been adopted by many general dentists and by dental specialists since its commercial introduction in 1959. The cumulative total of units sold through the close of 1975 has been estimated to be between 13 and 15 thousand [18].

A major object of research in dentistry has been to increase the durability of restorations [30] [29] [10]. One of the newer developments, composite resin filling material, is already the first choice of many dentists for restorations that require cosmetic color shading and are not on biting surfaces. Previously, silicate cements were used for most fillings in the teeth where natural appearance was a consideration. When properly used under suitable conditions, composite restorations can be placed in about the same length of time as can silicate restorations, and are expected to last 8 to 10 years, about twice as long as silicate. The eventual saving of manhours used for restorative work should be considerable.

Any time-saving from developments in restorative materials, now or in the future, will accrue very slowly and will affect only that proportion of the dentist's time that is devoted to doing filling-type restorations. This proportion of time has been steadily declining, from 43.0 percent in 1958 to 37.8 percent in 1964 and to 29.7 percent in 1971 [40].

Designing the work area for improved traffic flow and work efficiency is often included as a part of dental office planning. Also, the development of new dental equipment that positions instruments and supplies more conveniently for the dentist and auxiliaries or that better illuminates the operating field or makes it more accessible to the dental team contributes to production increases. Although the benefits of proper office layout and selection of equipment and material

are often obscured by other characteristics of a dental practice, progress in office design has undoubtedly contributed to enhancing dentists' productive capability.

Nitrous oxide analgesia has been gaining adoption in the 1970's as a safe, fast-acting means to reduce anxiety, pain sensitivity and reaction to gain efficiency in treatment [13]. Because patient recovery to full altertness is rapid as compared with other analgesic methods in use, patients' chair time is reduced. Also the development and widespread use of more effective and reliable local anesthetics are thought to have increased efficiency.

Pre-packaged, sterilized, and disposable dental supplies are increasingly available. Automatic X-ray film developers are now available that reduce the staff time used for film development. The ultrasonic tooth-cleaning equipment that has been widely adopted reduces fatigue for the dentist or hygienist and improves patient acceptance of the procedures for removing hardened accumulations from the teeth.

## Organizational Change In Dentistry

Like the engineering advances previously discussed, changes in the configuration of the dental practice, primarily in the utilization of various types and numbers of allied dental health personnel, have acted to enhance the productive capability of the Nation's stock of dentists. The most significant elements of organizational change will be discussed in this section.

## Division And Specialization Of Labor In Dentistry

The modern delivery of dental care is characterized by extensive division and specialization of labor both inside and outside the dental office practice. The categories of dental auxiliaries and allied personnel which participate in the modern dental care delivery system are described below.

Dental Assistants: The dental assistant assists with the direct care of dental patients under the supervision of a dentist. The scope of the assistant's responsibilities is influenced by the employer, educational preparation, and the regulations of the Dental practice act of the State in which the dental assistant is employed.

In contrast to most allied health occupations, comparatively few dental assistants are formally trained; many are trained on-the-job. In 1970, the number of formally trained assistants was estimated to be 9,200, less than 10 percent of the total active number (112,000). The job classifications of dental assistants are numerous, and range from individuals whose responsibility is essentially that of an office maid to the highly skilled expanded function dental auxiliary.

Dental Hygienist: The dental hygienist provides oral prophylaxis services, instruction in dental health education, and applies topical agents such as fluorides. While the majority of dental hygienists are employed in private dental offices, many are employed in public schools, State and local health clinics, hospitals, industry, and voluntary health agencies.

Graduation from high school is a requirement for entrance into a dental hygiene education program. Many community colleges and other training institutions offer a 2-year dental hygiene program and award a certificate or associate degree. Many colleges award a bachelor's degree with a major in dental hygiene. Some dental schools also offer a 4-year dental hygiene program leading to a bachelor's degree. Several schools offer a master's degree in dental hygiene education; this course of study is 1 or 2 academic years beyond the 4-year bachelor's degree [36].

Dentists' employment of dental hygienists has increased significantly since 1950 when only six percent of the dentists employed a dental hygienist. In 1959, 14 percent employed a dental hygienist. By 1973, well over 25 percent of the practicing dentists were using dental hygienists [1] [2] [3]. The contribution of dental hygienists to the productive capacity of the dental office results primarily from the fact that the hygienist can function, under supervision of the dentist, as an independent member of the dental service team. The hygienist, in providing services independently, frees the dentist to perform more of other procedures requiring other specialized skills.

Dental Laboratory Technicians: Most dental prostheses are made to the order of the dentist by dental laboratory technicians in commercial dental laboratories. There are now more than 12,000 dental laboratories

employing more than 41,000 technicians skilled in various aspects of prosthesis construction. The procedures involved in prosthetic construction profit by division of labor; technicians specialize in porcelain work, gold, etc. This specialization of function and division of labor within it has significantly increased the output capacity of dentistry through transferring a time-consuming technical specialty to an independent group of allied dental personnel.

## The Evolution Of Division And Specialization Of Labor In Dentistry

Innovations in dental equipment--the single most significant being the high-speed handpiece--have precipitated many of the significant organizational changes in dentistry. The speed and ease with which hard tooth structures could be cut with the high-speed handpiece not only increased the amount of work a dentist could do at each appointment but also led to a major organizational change: the practice of four-handed, sit-down, quadrant dentistry.

Research on the efficient utilization of auxiliary personnel and documentation of their contribution to the production capability of the dentist dates back to the early World War II era. However, the major thrust in research and development efforts didn't really begin until the mid-1950's, the same period of time in which the high-speed dental handpiece was developed and introduced [14].

Four-Handed, Sit-Down, Quadrant Dentistry: As has been previously noted, one of the ramifications of using the high-speed dental handpiece was the necessity of using water spray coolants. In order to eliminate the need for the patient to constantly sit up and expectorate during the restorative procedure, the high-volume oral evacuation systems were developed. An accompanying innovation, influenced by the operator working from a seated position, was the introduction of the lounge-type dental chair.

With the patient able to comfortably maintain the same position throughout a procedure, the mode of treatment in the dental office could be structured in a more efficient manner. The dentist could operate in a seated and less fatiguing position while maintaining continuous visibility and easy accessibility to the patient's oral cavity. A dental chairside assistant could function in a manner similar to the operating room surgical nurse. Arranging the needed dental instruments and supplies so that they were immediately accessible at chairside allowed the assistant to also assume a seated and less stressful position. This allowed the assistant to perform several important functions, including retracting oral tissues and operating the high-volume suction system to keep the operating field clear of debris. By utilizing the services of a trained dental assistant throughout the treatment procedure the dentist was able to focus attention nearly exclusively on the operating field and to work without interruption. Significant time savings resulted. For example, the average sitting required 45 minutes

to an hour in 1950, whereas the same type of treatment took from 20 to 35 minutes in 1973 [1] [3]. Moreover, the increased efficiency and speed with which the dentist was able to operate allowed him to treat not just one tooth but all teeth needing treatment in the same quadrant of the mouth during the same sitting.

It is the arrangement of the dentist and chairside assistant in seated positions, with the dentist providing needed treatment to all of teeth in the same area or quadrant of the mouth while having continuous assistance from the chairside auxiliary, that is described by the term "four-handed, sit-down, quadrant dentistry." The gradual acceptance of and the adaptation to the concept and practice of four-handed, sit-down, quadrant dentistry followed an extensive research, demonstration and training effort supported by the Public Health Service to be described below.

Dental Auxiliary Utilization Program: In 1956, the Public Health Service supported experimental training projects in six dental schools to examine the feasibility of teaching dental students the concepts and practice of four-handed, sit-down, quadrant dentistry. These projects proved to be successful and therefore were used as prototypes of training programs that were eventually established in all U.S. dental schools [44]. In 1961, the U.S. Congress appropriated funds to establish the Dental Auxiliary Utilization (DAU) Training Grants Program [19]. The purpose of the program was to increase dentists' productive capability

by encouraging them to adopt innovative methods, including: (1) the extensive use of auxiliary personnel, with particular emphasis on the use of chairside assistants and on expanding the clinical functions performed by auxiliaries; (2) the use of time and labor saving techniques and equipment (e.g., equipment for the practice of four-handed sit-down dentistry); and (3) the use of office management practices intended to facilitate patient flow and treatment control.

The DAU program was initiated in response to a predicted shortage in dental manpower. It was felt that the optimal utilization of trained dental auxiliaries could significantly increase clinical production capacity, thereby helping the profession to meet increasing demands for dental services. By 1969 all of the U.S. dental schools had active DAU programs providing didactic and clinical DAU training to the dental student. Although the DAU Grants program ceased in 1970, all dental school curricula still provide the student with education in the utilization of auxiliary personnel.

Training in Expanded Auxiliary Management Program: In 1965 the Public Health Service began a 5-year project in a specially designed dental facility for experimental study in Louisville, Kentucky, to investigate the feasibility of expanding the functions of the chairside dental assistant [25].

To implement the results of research on expanded function auxiliaries carried out at the Louisville facility, the Public Health Service initiated the Training in Expanded Auxiliary Management (TEAM) Grant Program in 1971 [38].

The purpose of the TEAM Program is to train dental students in the organization and management of a dental practice which uses the "team" approach to the practice of dentistry. At a minimum, the team is based on the concept of four-handed dentistry and includes the utilization of expanded function auxiliaries. The training provides instruction and clinical experience to enable students, upon graduation, to develop and manage a dental team in their dental practices. Between 1971 and 1976, 37 dental schools received Federal support for TEAM programs, and approximately 4,820 dental students have been trained in these programs. There are 1,500 students currently receiving TEAM training in 27 ongoing programs. About 63 percent of those students graduating from schools participating in the TEAM program are fully trained in expanded auxiliary management [32].

Although the number of dentists graduating with special training in the TEAM mode of dental practice to date is relatively small, a number of States have changed, or are in the process of changing, their State dental practice laws to permit dentists greater flexibility in the delegation of functions to auxiliaries. At the end of 1973, there were 44 States which, to varying degrees, had authorized expanded functions either by amendment of the State dental law or by issuance of appropriate regulations by the Board of Dentistry [38].

Expanded Function Dental Auxiliary Program: Success of the TEAM program will be manifested in an increased demand for dental auxiliaries trained in expanded functions. To meet the anticipated demand, the Health Manpower Act of 1971 (P.L. 92-157) included an Expanded Function Dental Auxiliary (EFDA) Program to support the training of undergraduate and practicing auxiliaries, research and development projects, and the development of educational materials for expanded functions. The Health Professions Educational Assistance Act of 1976 (P.L. 94-484) revised and extended the EFDA Program.

The term "expanded function dental auxiliary" refers to dental hygienists and dental assistants whose training includes a wide range of clinical functions and direct patient care procedures previously performed only by the dentist. Performing these functions and procedures enables the auxiliary to support and extend the efforts of the dentist. Since 1972, 61 projects have trained approximately 7,000 auxiliary personnel in expanded functions [38].

The extent of proper expansion of dental auxiliary functions is currently a controversial issue. The American Dental Association recently reversed its long-standing position in favor of expanded functions for dental auxiliaries. This reversal followed many recent revisions to State dental practice acts which the ADA and State dental societies supported. The withdrawal of support for expanding the role

of dental auxiliaries in dental office practice may reflect the current economic conditions of the dental market which was gravely affected by the recent economic recession. A possible reversal of the current attitude may occur with the recovery of the national economy.

## Changes In The Business Organization of The Dental Practice

Solo practice is still the predominant private organizational arrangement in the practice of dentistry. Organizational changes in the business arrangement of dental practice have taken place only slowly in recent years. While a trend toward group practice formation has been observed, it is obscured by lack of a consensus on the definition of a group practice in terms of both the legal organizational arrangement and the number and/or types of dentists constituting a group.

A study undertaken in 1970 by the Public Health Service resulted in the identification of 715 groups which met the definition of a group dental practice as "a practice formally organized to provide dental care through the services of three or more dentists using office space, equipment and/or personnel jointly." While it was recognized that the study did not include all practices operating as groups in 1970, it did indicate a trend toward group practice and identified some of the prevalent group practice characteristics. Groups ranged in size from

three to 30 members, and the average number per group was 4.4 dentists. Of the groups reporting, slightly more than one-half were general practice groups, approximately one-fourth provided specialized care only, while the remainder were made up of general practitioners together with specialists in other fields of practice. Two-thirds of the individual dentists in the survey were general practitioners [43].

While group practices have been promoted as a means of improving productivity while maintaining quality and increasing cost-effectiveness, little research has been conducted to support these assertions. For the purpose of this paper, the relevant question is: Do economies of scale characterize the practice of dentistry? A major study addressing this question is currently being supported by the Division of Dentistry.

## Prevention Of Dental Disease

### Dental Caries Prevention

Community Water Supply Fluoridation: The beneficial effects of optimal fluoridation of community water supplies on the dental health of children and young adults is thoroughly established and documented. As of the end of 1975, there were among the 94 million Americans in the age range from birth to 24 years, about 26 million who were born in fluoridated areas and who will evidence the full benefits of fluoridation.

They will as a group have less than half as many decayed teeth as their counterparts in nonfluoridated areas. A significant percentage of them will be free of any tooth decay through early adulthood; nearly all persons in the same age bracket who were born in nonfluoridated areas will have accumulated tooth decay beginning in early childhood. Similarly, the group with the advantage of fluoridation from birth will have lost far fewer permanent teeth as compared with a like group without optimal fluoridation. For most of the 26 million who continue to reside in a fluoridated area, the benefits will extend well into middle age. Millions of other persons who were already in infancy and early childhood when fluoridation began in their areas will also accrue lesser but very significant dental health benefits.

The proportion of the population that can be expected to show these dental health gains will be constantly increasing. Almost one-half of the U.S. population is now served by water supplies that have an optimally adjusted concentration of fluoride [41]. This coverage is increasing steadily, although the rate of increase has slowed in recent years. The pace has slowed partly because most of the water supplies not yet fluoridated serve the smaller U.S. communities, so that each additional local action to institute fluoridation affects a smaller increment of the total population. Also, the organized activities of persons who oppose fluoridation on political or philosophical grounds have become more effective in the last few years, and have blocked or delayed

implementation in some jurisidictions. The U.S. Congress has not yet provided Federal financial assistance to the States for community fluoridation, a program that has been proposed in recent sessions of Congress as a part of a broader legislative approach to dental disease prevention and dental care for children.

The limit of potential coverage by fluoridation is determined by the number of people served by public water supplies, estimated in 1974 to be about 170 million out of a total U.S. population of 210 million [37]. The other 40 million persons now using individual supplies or very small public water systems cannot readily take advantage of water fluoridation. For these there are other applicable preventive dental health measures that are beneficial but which have so far proved to be less effective than optimal water supply fluoridation.

The dental health benefits of optimal water fluoridation are known [5] [9]; there is also considerable evidence concerning the reduction of treatment needs of children and young adults who have had the advantages of fluoridation [47]. A study conducted by the New York State Health Department showed that a program of complete dental care (except orthodontics) for 5 and 6-year-old children in a fluoridated community cost only about half as much per child and required about half as much chairtime as the same program in a nonfluoridated area. In the fluoridated area, 41 percent of this age group had no tooth decay at all versus only 17 percent decay-free in the nonfluoridated area [7]. A dental health insurance carrier has reported a much greater proportion of smaller claims and far fewer large claims for children up to age 19

from fluoridated communities as compared with claims covering the same age group in communities not fluoridated [15]. Navy dental researchers, in surveying the dental health of young Navy recruits for several years, have found an increasing proportion of them to be free of tooth decay, and have attributed the change to the fluoridation of water supplies in the recruits' home communities [23].

These findings further confirm the results reported in scores of similar studies and surveys of children and young adults in the U.S. and in several other countries. They further affirm the dental health benefits of continuously using a fluoridated water supply from birth or very early childhood. There are also some studies from naturally fluoridated areas in the U.S. and abroad which show that the decay prevention benefits of continuous use extend well into middle age or even throughout life [17] [26] [27].

There is far less information about the effect of continuous long-term use of fluoridated water on the dental care needs and demands of older adults as the useful life of more of their natural teeth is extended into older age. This developing trend will eventually result in a greater number of adults who will be enjoying the obvious advantages of natural teeth, but who may also continue to be at risk to periodontal disease, the further occurrence and progression of tooth decay, and the need for replacement of restorations. Such dental developments later in life presumably will require professional

care that would not be required by persons who had lost more of, or all of, their teeth earlier in life. This still undetermined factor will grow in importance with the statistical increase in the average life span and the increase of the proportion of the elderly among the U.S. population.

It may be hypothesized that the dental health effects of the lifetime use of optimally fluoridated water on a cohort of persons born into a fluoridated community will become most evident in two separated periods. First, during their childhood, adolesence, and early adult years, their need for restorations and extractions will be dramatically reduced as compared with a similar cohort in an unfluoridated area. Many of them may continue to enjoy the benefits of reduced need through their middle age.

Then, as these groups grow older, another important difference may be observed. Among the elderly continuous residents in the fluoridated area, there will be more persons who have retained more of their natural teeth, with an attendant need for continuing dental care, such as cleaning, restoration, replacement of old restorations, and periodontal treatment, and a reduced need for preparation and maintenance of partial and complete dentures. Thus, it may be that in a fluoridated community, the long-term effect of fluoridation on dental care practice may be a reduction in the demand for restorative work among children and younger

adults, an increase in the demand for the services of the general dentist, the periodontist, the endodontist and the hygienist for older adults, and an overall reduction in the demand of all age groups for prosthetic services.

Until more explicit quantitative information on the dental care demands of affected adults is developed, predicting the total actual effect of existing or future optimal fluoridation on overall dental care demand will remain an uncertain venture. It is primarily for that reason that the dental health benefits of fluoridation are not introduced as a factor in the projections of the future requirements for dental health personnel that are discussed in this report.

School Water Supply Fluoridation: Fluoridation of rural school water supplies has been instituted in recent years in several States as a dental caries preventive for children in locales not served by public water supplies [6] [35]. To compensate for the fact that the children use the school water supply only part-time, a higher fluoride concentration is maintained than in fluoridated community water supplies [8].

The reductions in tooth decay among children who enter these schools at five or six years of age and attend for several years are comparable to the 30 to 35 percent reductions seen among children of the same age who began using a fluoridated community water supply at the age of five or six [20] [21] . These dental health benefits are obviously significant for children and youth. There does remain a question about the degree to which the gained benefits are retained through the years

after the child or young adult has left the school and its fluoridated water supply. Limited data from community fluoridation experience indicate that continuous maximum benefits are dependent on continuing use of a fluoridated supply, or some individual means of continuing maintenance of fluoride in the tooth surface, such as fluoride rinses, professionally applied fluoride pastes or gels, or chewable fluoride supplements [39].

Topically Applied Fluorides: Some modes of topical applications of fluoride solutions, gels, or pastes to the teeth have proved to be effective in reducing the subsequent occurrence of tooth decay [12] [22] [46]. The most effective topical treatments are those applied with optimal frequency by dental personnel to teeth that have been professionally cleaned.

Mass preventive programs using topically applied fluorides (mouthrinses) are being provided to children through schools in some areas. As compared with dental office treatment of individuals, such programs offer great economies in the time of professional personnel, in overhead cost per patient and in the time required for education and motivation of the individuals who participate. The effectiveness of such mass-prevention programs is, for various reasons, less than that of professional preventive treatment on an individual basis. Again, as in all preventive dental health programs based on school attendance, there remains the question of the duration of measurable benefits. Given that the children do not enter the school system until they are five or six

years old and thus can have a maximum of nine years of supervised topical fluoride use, the prospects are that the further preventive effect will be short-lived after they leave school. These programs should reduce the restoration work of dentists who provide care to school-age children in specific locations. The adoption of school-based fluoride programs, not now widespread, is being promoted by Federal, State and local health agencies, so further growth of such programs may be anticipated.

The maximum effect of such programs on manpower requirements in any locality will not be generally evident for a decade. Reconsideration of the effect after that time will be appropriate if the mass prevention programs have been widely adopted and sustained.

Periodontal Disease Prevention

Periodontal disease is the presence of inflammatory conditions affecting the tissues surrounding and supporting the teeth. When only the gum tissue (gingiva) is affected, the disease is called gingivitis, but when the process extends below the junction of the gingiva with the tooth surface and affects the subgingival bone and tissues, it is known as periodontitis.

When periodontal disease is present, the gums often appear abnormally red and slightly swollen and tend to bleed, sometimes profusely, when the teeth are brushed. The gums may become thickened and scarred, and they may recede, exposing the root surface. As the disease advances, the attachment of the gum to the tooth is lost, creating open pockets

extending below the gum-tooth junction. More of the gum tissue is destroyed, and the ligaments and bone surrounding the roots deteriorate. Finally, the teeth become loose, abscesses form, and the teeth are lost.

The following summary of the periodontal disease situation is excerpted from a 1976 report of a scientific evaluation panel on periodontal disease research to the Director of the National Institute of Dental Research [45].

> Periodontal disease is a major health problem which is of increasing concern in our society; it becomes more prevalent and much more severe with increasing age. It is the principal cause of tooth loss after the age of 30 years. The disease afflicts two out of three middle-aged Americans. Projections based on the latest population figures indicate that of the 127 million adults in the United States who retain some of their teeth, about 94 million have periodontal disease; of these approximately 32 million have some advanced form. Of the nearly 23 million persons in this country who have lost all of their teeth, a large portion have lost them as a result of periodontal disease.
>
> Contrary to common belief, periodontal disease is not confined to the adult population. Gingivitis, which usually progresses to periodontitis with the passage of

time, is observed in four out of five individuals by the age of 15. Furthermore, about 4 percent of these children have frank periodontitis.

Treatment of chronic periodontitis is an arduous, time-consuming, and expensive task. Treatment of severe cases may require from 6 months to 2 or 3 years, and may cost several thousand dollars. In moderately severe and severe cases, treatment is done by dental specialists who have had training of 2 to 3 years beyond that of the dentist. For these reasons, treatment has generally been limited to a very small segment of the population. This situation is unlikely to change in the foreseeable future.

The prevention of periodontal disease today remains dependent on a regular, intensive, personal oral hygiene regimen of brushing and flossing, usually reinforced by professional instruction, examination, and periodic professional cleaning of the teeth. Even with such an effort, avoidance of periodontal disease is not a certainty. Such prevention now represents a rather small effort, as recent data show that only about 50 percent of the U.S. population visits a dentist even annually, and only 15 to 20 percent visit a dentist regularly.

Progress toward public awareness of the periodontal disease problem and motivation toward improvement of the situation remains in a very early phase. The dental profession must still convince the American

public en masse that (1) periodontal disease and the resultant loss of teeth is widely prevalent, but not inevitable, and that (2) personal oral hygiene effort under professional guidance is, for now, the only practical preventive.

There are research projects aimed at the prevention of periodontal disease by means of mouthwashes that inhibit the formation of dental plaque, by the study of resistant animals and people for a possible immunizing factor, by the improvement of tooth and mouth cleaning techniques and by other means. The successful application of any practicable measures that may be developed from these projects would still require individual decision and action.

If the preventive action that is already possible for individuals ever becomes a national common practice, the effect on professional dental care needs of adults will be at least as great as the effect of fluoridation on childrens' dental care needs. The effects on demand cannot be estimated from the very limited information that is now available.

## Third Party Payment

In recent years the growth in "dental insurance" or, more accurately, prepaid dental coverage, has been remarkable. About three quarters of a million Americans had some type of dental coverage in 1960, more than twice as many as in 1958. By the end of 1964, the number covered had almost reached one and a half million. It has grown to over 30 million today.

Most non-governmental third-party payment plans are sponsored by a union-employer arrangement, negotiated through collective bargaining. Most of the growth in prepaid dental care plans has stemmed from this type of fringe benefit negotiation. These arrangements account for more than two-thirds of the persons covered under dental prepayment. The major impetus toward expansion of dental prepayment will probably continue to come from this source as union contracts come up for renegotiation.

The major dental insurance contracts are very comprehensive and extend coverage to large groups of people at one time. For example, the trend-setting United Auto Workers/Auto Manufacturers' Contract of 1974 is very comprehensive and covers three million people. In 1975, the United Steel Workers of America obtained a similar dental benefit covering 1.2 million people. Early in 1976, the American Telephone and Telegraph Company (including Western Electric) and the International Brotherhood of Electrical Workers/Communication Workers of America negotiated a benefit package covering nearly three million beneficiaries. A new dental benefit negotiated between the National Railway Labor Conference, representing 300 railroads and 14 national rail unions covering 1.5 million employees and dependents, also became effective in 1976.

No comprehensive studies of the dental insurance phenonemon have yet been completed. Therefore, the major question to be addressed, as far as projection of the percent of the population covered under dental prepayment is concerned, is whether or not an estimate of the growth of prepayment can be established.

As mentioned above, growth in the number of people covered by dental prepayment plans in the recent past has been closely linked to collective bargaining. Of the population presently covered by a prepayment plan, only 8-10 percent are not covered by a company plan. If one assumes that by 1990 all union members and their dependents will be covered by dental prepayment plans, and that union families continue to comprise their present proportion of the population, then by 1990 one can foresee that a little over one-third of the population will be covered by dental insurance. Adding 10 percent for non-union or individual plans indicates that an anticipated 43 percent of the population will be covered.

Another way to approach the problem of projecting dental benefit coverage is to draw a parallel between the growth of dental benefits and similar phenomena. One such parallel drawn by commercial insurers is that with the growth of major medical coverage. Table 4 shows the growth in major medical coverage from 1955 to 1974.

Table 4: Growth of Major Medical Coverage, 1955-1974

| Year | Percent of Population Covered by Major Medical |
|---|---|
| 1955 | 3.2 |
| 1960 | 14.0 |
| 1965 | 27.3 |
| 1970 | 37.6 |
| 1974 | 43.0 |

Source: Health Insurance Institute, Source Book of Health Insurance Data 1975-76, The Institute, 1976.

To draw the parallel, one begins with the year 1970 when 6 percent of the population was covered by dental insurance and the rate of growth of dental insurance coverage was just "taking off." This was comparable to the major medical situation in 1955. By 1975, 33 million people or 15.5 percent of the population had dental benefits, compared to 14 percent covered by major medical in 1960. Continuing the parallel, and projecting to 1990, one would project that about 43 percent of the population will be covered by dental benefit plans which is analagous to the 43 percent covered by major medical in 1974. This is approximately the same percentage arrived at in the alternative reasoning discussed in the previous paragraph.

Are there any foreseeable developments that would cause one to raise this estimate? A recent event which might warrant a revision is the recent United Auto Workers-Ford Motor Company agreement that retired auto-workers be covered by union dental benefit plans to compensate for the lack of such coverage under Medicare. The potential increase in the proportion of the population covered by gradual adoption of such coverage in collective bargaining proposal might be significant. However, careful studies of the actual use of the dental benefits by this population group are needed to establish their patterns of utilization.

Another development that has substantial implications for the problem being considered is the recent reduction in the size of eligible groups for dental coverage in many private plans from one hundred individuals to as few as two individuals. If the potential of this development is realized,

it could contribute a significant marginal increase to the proportion of the population covered by prepaid dental care over the next fifteen years.

A tentative conclusion based on these additional considerations is that a projection of 50 percent coverage of the population by 1990 might be warranted. Although currently thought to be optimistic, it can represent a liberal expectation of the upper bound on the extent of prepaid dental coverage.

References For Appendix B


1. American Dental Association: The 1950 Survey of Dental Practice, ADA Bureau of Economic Research and Statistics, Chicago, Illinois, 1951.

2. American Dental Association: The 1959 Survey of Dental Practice, ADA, Bureau of Economic Research and Statistics, Chicago, Illinois, 1961.

3. American Dental Association: The 1973 Survey of Dental Practice, ADA, Bureau of Economic Research and Statistics, Chicago, Illinois, 1974.

4. American Dental Trade Association: 1962 Survey of Dental Practice Requirements, ADTA, Washington, D.C., 1962, p. 9.

5. Arnold, F.A., Likins, R.C., Russell, A.L., and Scott, D.B.: "Fifteenth Year of the Grand Rapids Fluoridation Study," Journal of the American Dental Association 65:780-85, December 1962.

6. Association of State and Territorial Dental Directors: "Association Recommendation Number 1 - Fluoridation of School Water Supplies," Biennial Conference, Chicago, Illinois, April 1969.

7. Ast, David B. et al.: "Time and Cost Factors to Provide Regular, Periodic Dental Care in a Fluoridated and Nonfluoridated Area," Journal of the American Dental Association 80:770-776, April 1970.

8. Bellack, Ervin: School Water Supply Fluoridation, U.S. Environmental Protection Agency, Water Supply Division, Washington, D.C., 1972. (Engineering Manual).

9. Blayney, J.R., and Hill, I.N.: "Fluorine and Dental Caries," Journal of the American Dental Association 74:233-302, January 1967 (Special Issue).

10. Brauer, G.N.: "Adhesives and Composites in Dentistry--Present and Future," Proceedings of the Symposium on Dental Biomaterials--Research Priorities, DHEW Publication No. (NIH)74-548, pp. 63-80, 1974.

11. Brown, William E. (editor): Oral Health, Dentistry, and the American Public, University of Oklahoma Press, Norman, Oklahoma, 1974, p. 340.

12. Carlos, James P. (editor): Prevention and Oral Health, DHEW Publication No. (NIH) 74-707, U.S. Government Printing Office, Washington, D.C., 1964, pp. 23-26.

13. Carnow, Ralph (UCLA, School of Dentistry): "Nitrous Oxide-Oxygen Sedation," in Kilpatrick, H.C., Work Simplification in Dental Practice, W.B. Saunders Company, Philadelphia, 1974, pp. 620-6.

14. Cranford, Charles O.: "The Potential Impact of the Dental Assistant on the Dental Manpower Problem" Reprinted from the Journal of Periodontology, Vol. 39, No. 5, September 1968.

15. Cross, Charles O.: "The Economics of Fluoridation," Journal of the Southern California Dental Association 36:499-500, December 1968.

16. Ellis, David A. (American Dental Trade Association, Washington, D.C.): Personal communication to Manpower Assessment Section, Division of Dentistry, USPHS, July 1976.

17. Englander, H.R., and Wallace, D.A.: "Aurora-Rockford, Illinois Study III. Effects of Naturally Fluoridated Water on Dental Caries in Adults," Public Health Reports 77:887-93, October 1962.

18. Faude, Jack (S.S. White Company, Philadelphia, Pennsylvania) Personal communication to Manpower Assessment Section, Divison of Dentistry, USPHS, July 1976.

19. Greene, John C.: "Comments on the TEAM Program of the Division of Dental Health," Journal of Dental Education, April 1971.

20. Horowitz, Herschel S.: "School Water Fluoridation," American Physician 1:85-90, June 1970.

21. Horowitz, H.S., Heifetz, S.B., and Law, Frank E.: "Effect of School Water Fluoridation on Dental Caries: Final Results in Elk Lake, Pa., After 12 Years," Journal of the American Dental Association 84:832-838, April 1972.

22. Horowitz, H.S., and Heifetz, S.B.: "The Current Status of Topical Fluorides in Preventive Dentistry," in Newbrun, Ernest, Editor: Fluorides and Dental Caries, Charles C. Thomas, Publisher, Springfield, Illinois, 1972, pp. 34-59.

23. Keene, H.J., Shklair, I.L. and Hoerman, K.C.: "Caries Immunity in Naval Recruits and Ancient Hawaiians," Naval Dental Research Institute; paper given at the 138th Meeting of the American Association for the Advancement of Science, Philadelphia, Pennsylvania, December 1971.

24. Kilpatrick, H.C., Work Simplification in Dental Practice, W. B. Saunders Company, Philadelphia, Pennsylvania 1974, pp. 410-22.

25. Lotzkar, S., Johnson, D.W., and Thompson, Mary B.: "Experimental Program in Expanded Functions for Dental Assistants, Phase 3 Experiment With Dental Teams," Journal of the American Dental Association 82:1067, 1971.

26. Murray, J.J.: "Adult Dental Health in Fluoride and Non-fluoride Areas. Part I. Mean DMF Values by Age," British Dental Journal 131:391-5, November 2, 1971.

27. Murray, J.J.: "Adult Dental Health in Fluoride and Non-fluoride Areas. Part 3. Tooth Mortality by Age," British Dental Journal 131:487-92, December 7, 1971.

28. Paffenbarger, G.C. Dental Research Section, National Bureau of Standards, Washington, D.C. Internal memorandum concerning time and dollars saved by high-speed turbine handpieces, August 1, 1967.

29. Paffenbarger, G.C., and N.W. Rupp: "Composite Restorative Materials in Dental Practice: A Review," International Dental Journal 24:1-11, 1974.

30. Paffenbarger, G.C., and Souder, Wilmer: "Physical Research," Journal of the American Dental Association 58:97-101, June 1959.

31. Pettit, G.C. "Panoramic Radiography," in Kilpatrick, H.C., Work Simplication in Dental Practice, W.B. Saunders Company, Philadelphia, 1974, pp. 206-16.

32. Smith, Lowell W.: "TEAM Program Summaries," TEAM Fact Sheet, U.S. Department of Health, Education, and Welfare, Bureau of Health Manpower, Division of Dentistry, Hyattsville, Maryland, 1977 (mimeographed).

33. Snedaker, Richard F., "High Volume Suction Systems for Oral Evacuations," in Kilpatrick, H.C., Work Simplification in Dental Practice, W.B. Saunders, Philadelphia, 1974, pp. 422-33.

34. Stewart, J.L., and Beiser L.F.: "Panoramic Roentgenograms Compared with Conventional Intra-oral Roentgenograms," Oral Surgery 26:39, 1968.

35. Stewart, W.H. (Surgeon General, USPHS): "The Federal Government's Interest in the Health Problems of the Nation," Speech delivered at Conference of Deans of Dental Schools, Miami Beach, Florida, October 10, 1967.

36. U.S. Department of Labor, and U.S. Department of Health, Education, and Welfare: "Dentistry and Allied Services," Health Careers Guidebook, Third Edition, Hyattsville, Maryland, 1972.

37. U.S. Environmental Protection Agency, Office of Water Supply: Inventory of Municipal Water Supplies, (Computer Data Bank), Washington, D.C., 1975.

38. U.S. Department of Health, Education, and Welfare, Bureau of Health Manpower, Division of Dentistry: Background Summary, Expanded Function Dental Auxiliary (EFDA) Program, Fy 72-Fy 77, Hyattsville, Maryland, 1976 (mimeographed).

39. _____: "Dental Health Losses from Discontinuation of Fluoridation," PPB-59, August 1973 (mimeographed).

40. _____: Dental Manpower Fact Book, Hyattsville, Maryland, 1976 (mimeographed).

41. _____: "Estimated Extent of Fluoridation, 1975," Hyattsville, Maryland.

42. _____: "Expanded Function Dental Auxiliary (EFDA) Program, Background and Summary," Hyattsville, Maryland, 1977.

43. _____: Group Practice of Dentistry...An Organizational Form for the Delivery of Dental Services, DHEW Publication No. (HRA) 77-8 Hyattsville, Maryland, 1977.

44. _____: Guidelines for the Dental Therapist (Expanded Function Dental Auxiliary) Training Program, Hyattsville, Maryland, December 3, 1973.

45. National Institute of Dental Research, (Ad Hoc Scientific Evaluation Panel): Evaluation of the NIDR Periodontal Disease Research Activity, Bethesda, Maryland, April 1976.

46. World Health Organization: Fluorides and Human Health, World Health Organization, Geneva, 1970, pp. 345-7.

47. Young, Wesley O.: "Fluorides and Dental Caries in Idaho: IV, Cost of Providing Care for Children in Fluoride and Fluoride-Deficient Areas," Idaho State Dental Association Newsletter, January 1957.



* U.S. GOVERNMENT PRINTING OFFICE : 1977 O-726-106/1283